75th ANNIVERSARY

ENGINEERING NEWS-RECORD

September 1, 1949

BUILDING A GREATER AMERICA

The epic of America is a story of its construction men and their vision. First by hand, then with machines, the American dream of a better way of life has been made real for many, but not yet for all. As we face the next half of the twentieth century, America's destiny will challenge all the physical and spiritual resources of the construction fraternity. To build a greater America, to make the American dream a reality for all peoples . . . to that challenge this issue is dedicated.

*

for "AGE RESISTANCE" these B. F. Goodrich Co. stacks are BYERS WROUGHT IRON

The important quality of "Age Resistance" which B. F. Goodrich Company puts into its tires is also a prime requirement in all plant equipment. When two new stacks, each 5-feet x 95-feet, were required at the Akron, Ohio, plant, the engineers specified wrought iron. The stacks were fabricated of Byers Wrought Iron ¼-inch plate by Ohio Machine and Boiler Company.

Unlined metal stacks face severe corrosive conditions, and unless proper safeguards are used, can easily become a maintenance headache. Carbon dioxide is always present as a combustion product, and some sulfur compounds are generally encountered. When these are dissolved in condensed moisture, a dilute acid is formed which causes severe damage to vulnerable materials. Even when initial conditions are not severe, foresight suggests the use of durable material. For the aggressiveness of attack may be aggravated at any time, by a change in fuels—by the use of economizers or steam-jet draft inducers—or by intermittent operation.

Byers Wrought Iron is a veteran in stack service and engineering records provide convincing evidence of its superior durability. Service ratios of two and three to one, as compared to ordinary stack materials, are not at all uncommon.

Wrought iron's resistance to flue gas corrosion is due to its unique character. Tiny threads of glass-like silicate slag, distributed through the body of high-purity iron, halt and disperse corrosive attack, and so discourage pitting and penetration. The fibers also anchor the initial protective scale, which shields the underlying metal.

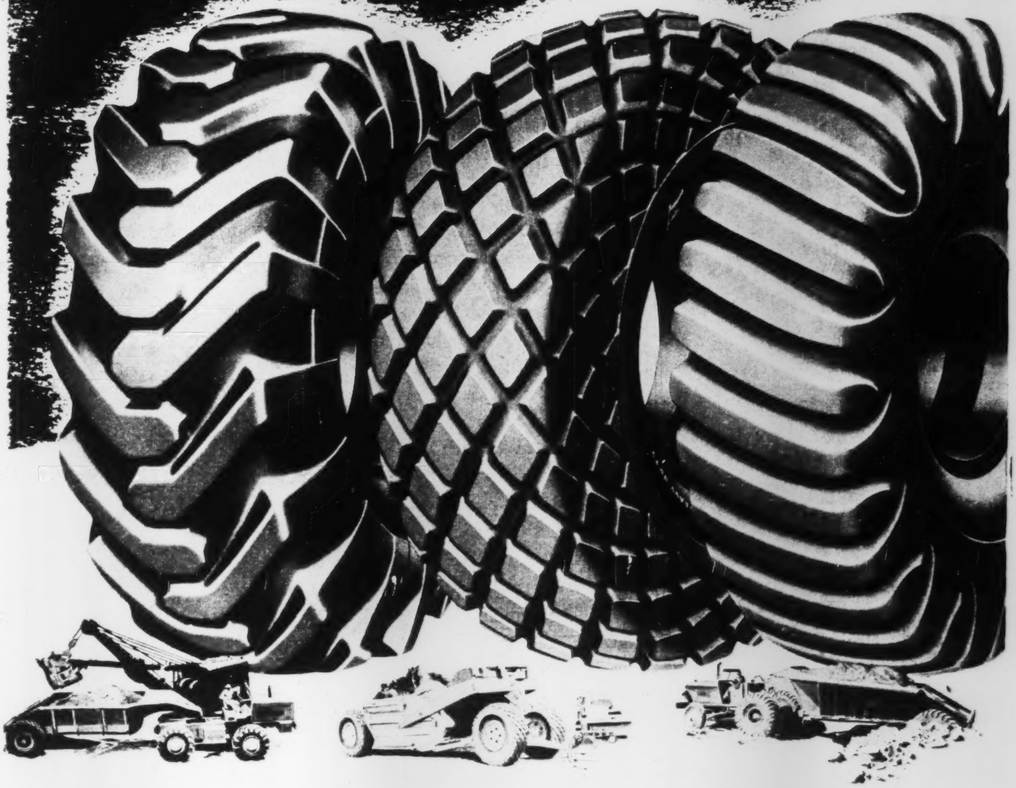
Our bulletin, WROUGHT IRON FOR FLUE GAS CONDUCTORS AND COAL HANDLING EQUIPMENT is filled with interesting and helpful information on stacks. May we send you a copy?

A. M. Byers Co., Pittsburgh, Pa. Established 1864. Boston, New York, Philadelphia, Washington, Atlanta, Chicago, St. Louis, Houston, Salt Lake City, Seattle, San Francisco. Export Division: New York, N.Y.

CORROSION COSTS YOU MORE THAN WROUGHT IRON

BYERS
GENUINE WROUGHT IRON
TUBULAR AND HOT ROLLED PRODUCTS
ELECTRIC FURNACE QUALITY ALLOY AND STAINLESS STEEL PRODUCTS

TOP THREE!



EARTH MOVER SURE-GRIP
for maximum traction on drive wheels

EARTH MOVER ALL-WEATHER
for drawn vehicles and general traction

HARD ROCK LUG
for super-stamina in all rock work

For trouble-free, long-lasting service—
to move more yards faster at lower cost—
always BUY and SPECIFY Goodyear—*it pays!*

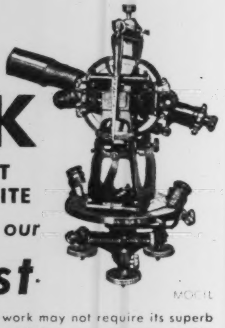
GOODYEAR

OFF-THE-ROAD TIRES

Sure-Grip, All-Weather—
T.M.'s The Goodyear Tire & Rubber Company

Both are
BERGER
–both are
BEST...

II-K
TRANSIT
THEODOLITE
is one of our
finest



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TRANSIT
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economy
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ACCURACY IN ACTION

in surface or underground surveying and engineering as well as in industrial use for measurement and alignment . . .

indeed, the world famous Berger skill of 77 years has accomplished both the 11-K Theodolite and the Transit for long life, sustained accuracy, few, if any, repair bills and the outspoken enthusiasm of thousands of distinguished users in American and Foreign industry.

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ENGINEERING NEWS-RECORD

VOLUME 143 SEPTEMBER 1, 1949 NO. 9

WALDO G. BOWMAN
Editor

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Have you *seen* the Northwest Truck Crane? Here is versatility that puts a whole line of equipment at your disposal — *on Rubber!*

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only the best for the heart of the job
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You can expect more from your building frames these days. Engine house structures, for example, last longer, decrease maintenance costs when made of Alcoa Aluminum. Aluminum stands up better than steel in the hot sulfurous fog of steam and coal gas in an engine house. That's proof of its performance for *your* buildings.

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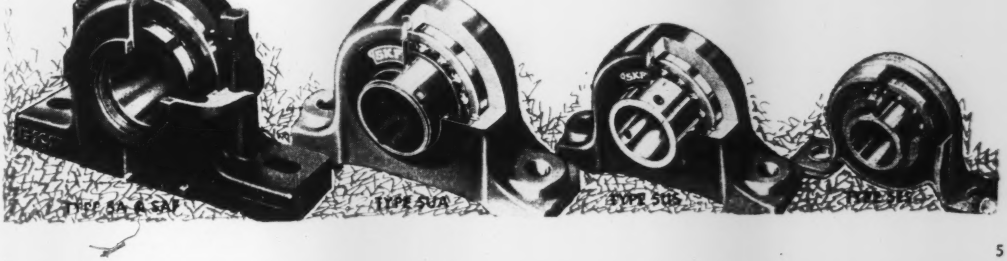
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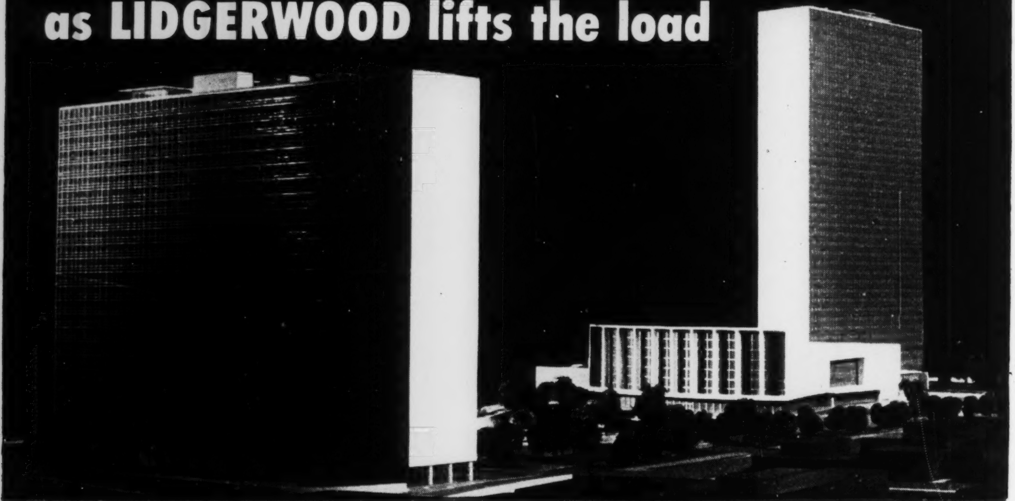
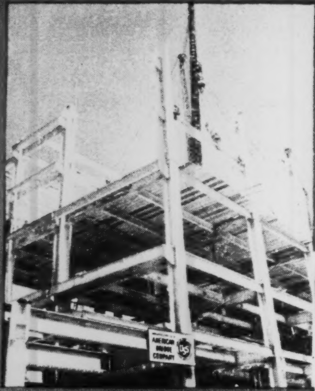
UN BUILDINGS ON THE WAY UP

as LIDGERWOOD lifts the load

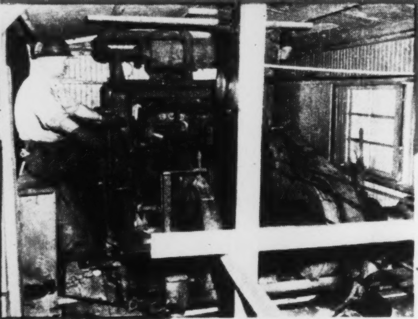




On the UN construction project, Lidgerwood Torque Converter Equipped Hoists are making many heavy lifting tasks easier.

This husky Diesel-or-gasoline-powered hoist provides the smooth, flexible control that literally "floats" heavy beams into place. It gives 100% speed and load control from a single lever. Responds like a steam hoist—but with the added advantages of greater economy, lighter weight.

A leader in manufacturing hoisting equipment since 1873, Lidgerwood has played an important part in large construction jobs both here and abroad. Superior-Lidgerwood-Mundy experience and equipment can help you solve your toughest hoisting problems—easily.



Lidgerwood Torque Converter Equipped Hoist—at work on UN building project.

- 100 H. P. Diesel Power Unit
- Hoist rating 10,000 lb. line pull
- At 210 feet per minute
- All Steel Construction
- Anti-Friction Bearings

OVER 200 YEARS OF ACCUMULATED EXPERIENCE
1869 MUNDY
LIDGERWOOD 1873
1895 SUPERIOR

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GET THE BEST *for your job!*

MURPHY DIESEL

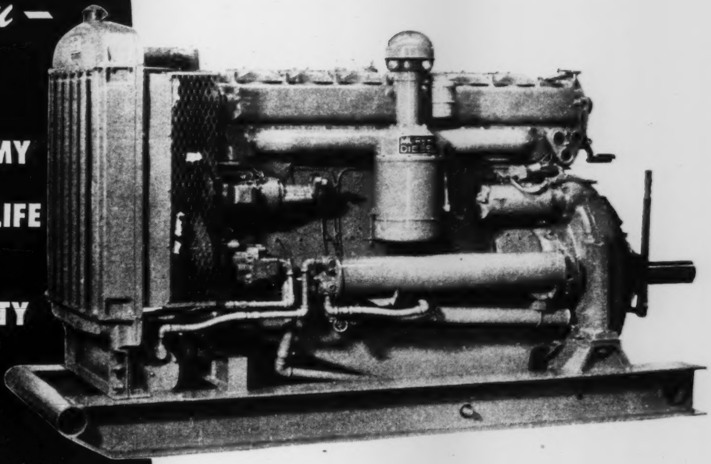
gives you —

MORE POWER

GREATER ECONOMY

LONGER ENGINE LIFE

GREATER DEPENDABILITY



YOUR engine must be the best — it's the heart of any job. For critical heavy equipment, rugged, heavy-duty Murphy Diesel Engines are your best assurance of steady power — lugging power that really hangs on to a load.

By staying on the job longer and more dependably, Murphy Diesels fatten up profits and help eliminate the costly delays that result from power failure. For direct operating economy, the Murphy Diesel uses less fuel than any other engine of comparable power rating — the combination of "true" diesel operation and unit fuel injection squeezes more work out of every drop of fuel.

Ask your Murphy Diesel Dealer to give you the whole story or write direct.

MURPHY DIESEL COMPANY
5311 W. Burnham St., Milwaukee 14, Wis.

MURPHY DIESEL

Heavy duty power

for construction

Murphy Diesel Engines and Power Units for the construction industry are available in sizes from 90 to 220 H.P. Generator Sets 60 to 133 K.W.

Literature describing Murphy's exclusive design features is available on request. Write today!

HARD STUFF IS A SOFT TOUCH WITH A BAY CITY

This Diesel powered BAY CITY 65 is making money out of stone for Rockydale Quarries Corporation of Roanoke, Virginia. Here is a shovel which boasts many features — easy operation with booster clutches • tandem drums in ball bearings • helical gears for quiet, smooth operation • powerful one-piece chain crowd • straddle type dipper sticks and big 1¼ yard dipper. To make any kind of tough excavating or material moving job easy, you can bank on a BAY CITY. See your nearest dealer or wire for information.

ROCKYDALE QUARRIES CORP.
VIRGINIA
BAY CITY

BAY CITY

SHOVELS CRANES • HOES • DRAGLINES • CLAMSHELLS

BAY CITY SHOVELS INC., BAY CITY, MICHIGAN See your nearest Bay City dealer for excavating and material handling equipment in sizes from ⅜ to 1¼ yard with crane rating up to 20 tons. Both crawler and pneumatic tire mountings.

No Twist-
No Stress-
No Strain
with
Mack Six-Wheelers

◆ That's because only Mack six-wheelers have the advantage of Mack's famed Balanced Bogie. Here's an outstanding development that means unmatched flexibility . . . mastery of the toughest terrain without stress or strain.

The exceptional flexibility of the Mack Balanced Bogie insures equal traction, even tire loading and uniform braking on all four wheels. Exclusive Mack Power Divider assures traction at all times, regardless of terrain.

Simplicity and rugged strength are typified in the functional construction of the Balanced Bogie. Maintenance requirements are reduced to a minimum. Outside of the brake system only four points on the assembly require lubrication. No place in the suspension ever needs adjustment.

For detailed information on how this and other Mack features can cut costs and increase profits on your particular job, see your nearest Mack branch or dealer.

IT'S PART OF THE LANGUAGE

Built Like a
Mack
Truck

Mack Trucks, Inc., Empire State Bldg., New York 1, N. Y. Factories at Allentown, Pa.; Plainfield, N. J.; New Brunswick, N. J.; Long Island City, N. Y. Factory branches and dealers in all principal cities for service and parts. In Canada: Mack Trucks of Canada, Ltd.

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RELIABILITY
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RCA

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INTERNATIONAL TELEPHONE & TELEGRAPH CORPORATION
AND ASSOCIATED COMPANIES

What have all these in common?

These famous names have *two* things in common. One is that they share the honor of being among the most respected trade names in the country. Among millions of consumers, they stand for the highest standards of care and quality in manufacture.

Another thing that they have in common—many of the products they represent are manufactured in a building or buildings constructed by the Turner Construction Company.

Over the years, the repeated selection of Turner by the leading companies in the country bears impressive evidence to the quality and satisfaction you, too, can expect when you "turn to Turner" with *your* building problems.

TURNER CONSTRUCTION COMPANY

FOUNDED 1902

420 LEXINGTON AVENUE, NEW YORK 17, N.Y.

BOSTON CHICAGO PHILADELPHIA

Euclid Service - YOUR KEY

DOUGALD CONST. CO

TO LOWER COSTS!

Engineered and built for heavy off-the-highway hauling, "Eucs" are first choice for open pit mining and quarry operations, and for construction and industrial work. Proved on hundreds of the toughest jobs, Euclid low cost performance is backed by a world wide distributor organization with competent personnel and stocks of genuine Euclid parts.

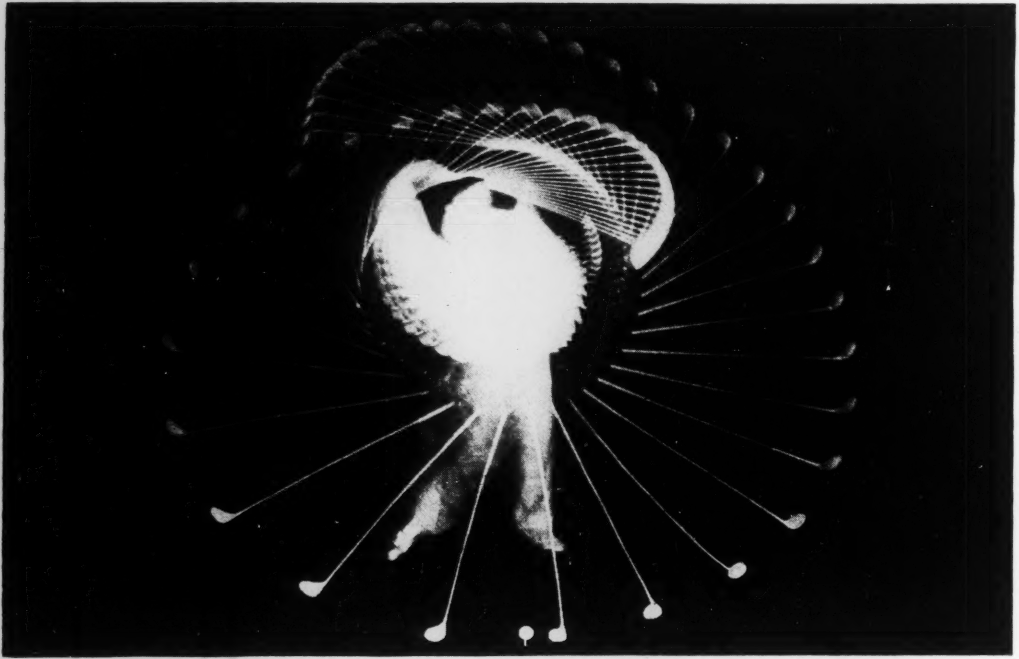
Euclid owners know they can depend on prompt and efficient service whenever needed to keep down-time and maintenance costs at a minimum. Your Euclid distributor will be glad to show you how dependable performance and fast on-the-job service can help to lower your hauling costs and keep your work moving on schedule.

First in field performance—first in service . . . these are Euclid plus values that add up to customer satisfaction.

The EUCLID ROAD MACHINERY Co., Cleveland 17, Ohio
CABLE ADDRESS: YUKLID

EUCLIDS *Move the Earth*

There's a **PATTERN OF PERFECTION** in Chlorination too



High-Speed photograph Courtesy of A. G. Spalding & Bros., Inc.

The champion's swing is a pattern of perfection, born of experience, practice and skill. The pattern of perfection in chlorination—proven ability to effectively solve chlorination's multitudinous problems—stems from the same background. W&T brings such a background to your job.

Whether you need chlorination for a drinking water supply, sewage treatment, a swimming pool or for industrial process and cooling water, you'll find that when you demand W&T equipment, you'll have all the ingredients for perfection—

EXPERIENCE gained through 35 years of research, development and pioneering—

PRACTICE based on making thousands of installations to meet a host of different problems—

SKILL inherent in a precision conscious factory and an able, alert field staff.

Call for the PATTERN OF PERFECTION on your next chlorination job—it's as close as your W&T Representative.

W&T Residual Chlorine Recorders provide permanent records of actual performance

WALLACE & TIERNAN
COMPANY, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

S-46

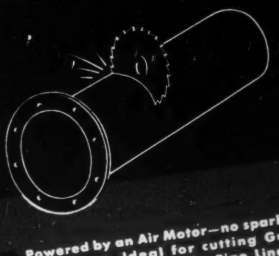
WACHS NATIONAL PIPE SAW

The Answer TO YOUR PIPE CUTTING PROBLEMS

Wachs National Pneumatic Pipe Saw Cutting 30″ Cast Iron Pipe. This same machine will cut cast iron or steel pipe from 12″ to 48″ in diameter.

●

Time Tried And Field Tested, This Wachs National Portable Pipe Saw, Shown Here, Has Been In Use By A Prominent Mid-West Gas Company For Eight Years.



SAFETY FEATURE Powered by an Air Motor—no sparks or flames. Ideal for cutting Gas and Petroleum Product Pipe Lines.

PORTABLE Two men can handle the machine. Weight approximately 260 lbs. Set up time approximately 15 minutes.

CLEAN, ACCURATE CUT A clean accurate milled cut is assured every time.

CUTS ON THE JOB Minimum 14″ clearance in ditch requires small excavation. Cuts above ground made with pipe on skids.

RUGGED CONSTRUCTION Welded steel body, alloy steel gears and shafts, bronze bushings, ball bearings and grease seals result in a machine which is built to stand rough service and can be operated by regular street crews.

A MILLING MACHINE ON WHEELS THAT CUTS PIPE CUTTING COSTS!

The Wachs National Pipe Saw travels around the pipe under two silent-type chains, which act as a flexible gear. The machine moves, the chains stand still. A complete cut is made in one revolution around the pipe with a feed rate of 2″ per minute. The result is an accurate milled cut that will meet the most rigid engineering specifications.

Cuts can be made above ground or in a ditch, under water or in the presence of explosive mixtures. This rugged, simple, portable machine saves time, saves labor, reduces hazards and can be operated by unskilled workmen.

Write today for a descriptive bulletin on this money saving machine.

THE E. H. WACHS COMPANY
Manufacturers of Engines, Valves and Machinery since 1883
1525 NORTH DAYTON STREET · CHICAGO 22, ILLINOIS

Du Pont Dynamite
starts the job on . . .

NEW $100,000,000 HUNGRY HORSE PROJECT

With the first canyon wall blast in the Flathead River Valley, Montana, the huge task of clearing away thousands of cubic yards of earth and rock for the Hungry Horse Dam begins. Work started on this Bureau of Reclamation project with the prime contractor, General-Shea-Morrison Co., using Du Pont Special Gelatin 40%.

Hungry Horse Dam, to be completed in 1952, will be the world's fifth highest and fourth largest concrete dam. It will impound a 34-mile-long lake with a capacity of 3,500,000 acre-feet of water and will generate 300,000 kilowatts of hydroelectric power. To divert the Flathead River during the construction of the dam, the contractors built a 1,180-feet-long tunnel, 36 feet in diameter.

Du Pont Special Gelatin 40% is ideal for jobs of this kind. It is an economical, plastic dyamite with excellent water resistance . . . maintains its efficiency in water-filled holes. It detonates at a high velocity and is well-suited for hard rock work.

No matter what the size of your blasting operation . . . whether a large project or small excavation job . . . it pays to call in a Du Pont Explosives representative. He may be able to show you how to do the job more efficiently, safely and economically.

E. I. DU PONT DE NEMOURS & CO. (INC.)
EXPLOSIVES DEPARTMENT
WILMINGTON 98, DELAWARE

DU PONT EXPLOSIVES

BLASTING SUPPLIES AND ACCESSORIES

Contractors Everywhere O. K. these Du Pont Blasting Products

DU PONT SPECIAL GELATIN

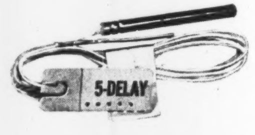
A water-resistant dynamite of high velocity. Plastic and cohesive. Excellent fumes.

DU PONT "GELEX"*

An economical, semi-gelatinous dynamite sufficiently water-resistant to meet most requirements.

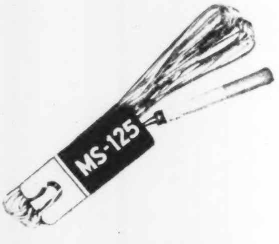
DU PONT "SERIES B" DELAY ELECTRIC BLASTING CAPS

This recent addition to the extensive line of Du Pont Caps is designed to eliminate risk of misfires due to arcing or "water hammer."



DU PONT "MS" *(millisecond)* DELAY ELECTRIC BLASTING CAPS

. . . reduce vibration . . . improve fragmentation . . . eliminate dynamite in muck. Come in fourteen delay periods with intervals clearly marked on tag.

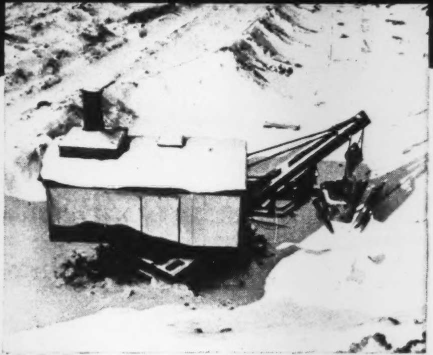


*TRADE MARK REG. U. S. PAT. OFF

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

When *This* THEW was sold "ENGINEERING NEWS" *was 29 years old!*

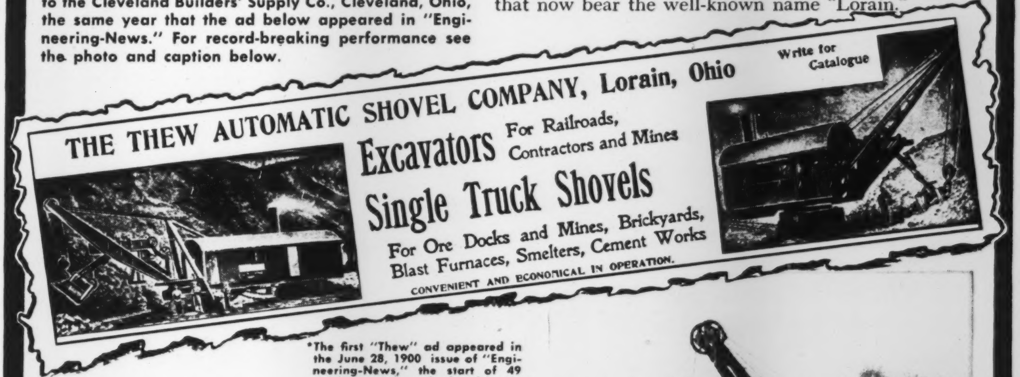


1903... The Thew Model 3A (above) was shipped to the Cleveland Builders' Supply Co., Cleveland, Ohio, the same year that the ad below appeared in "Engineering-News." For record-breaking performance see the photo and caption below.

The July 2, 1903 issue of "Engineering-News" (forerunner to Engineering News Record) carried the message reproduced below. The Thew Automatic Shovel Co. of Lorain, Ohio, was already 4 years old. Records were in the making!

That same year Cleveland Builders' Supply Co., Cleveland, Ohio, began a long-time career of "Thew" ownership that has lasted 46 years so far. Thew products already were on their way to the leadership that now makes the name "Lorain" *first* in the commercial shovel-crane field.

Since the very beginning, Thew has pioneered. The following *"firsts"* have contributed much to the modern, efficient and economical power shovels and cranes that now bear the well-known name "Lorain."



THE THEW AUTOMATIC SHOVEL COMPANY, Lorain, Ohio

Write for Catalogue

Excavators For Railroads, Contractors and Mines

Single Truck Shovels

For Ore Docks and Mines, Brickyards, Blast Furnaces, Smelters, Cement Works

CONVENIENT AND ECONOMICAL IN OPERATION.

*The first "Thew" ad appeared in the June 28, 1900 issue of "Engineering-News," the start of 49 continuous years of advertising in this publication and its successor, Engineering News-Record.

- **1895**... *first* full-revolving, mobile wheel type shovel.
- **1903**... *first* single-motor electric machine, also using friction type clutches.
- **1918**... *first* full-revolving crane mounted on a motortruck, forerunner of the "MOTO-CRANE."
- **1925**... *first* with new design principle of "big capacity at minimum weight" with the 1½ yd. Lorain-75.
- **1939**... *first* with a rubber-tire carrier designed exclusively as a shovel-crane mounting... the MOTO-CRANE.
- **1945**... *first* with a "never built or sold before" postwar machine... the radically new and different TL-20.

1949... After 45 years of faithful service, old "3A" was finally replaced by the modern 1¾ yd. Lorain-80 above. Cleveland Builders' Supply have purchased a total of 17 Thew-Lorains.

Today, Thew-Lorain is 50 years young ... and with its still aggressive pioneering spirit will carry on Thew-Lorain leadership into the future.

THEW-LORAIN 50th ANNIVERSARY 1899 1949

THE THEW SHOVEL CO., LORAIN, OHIO

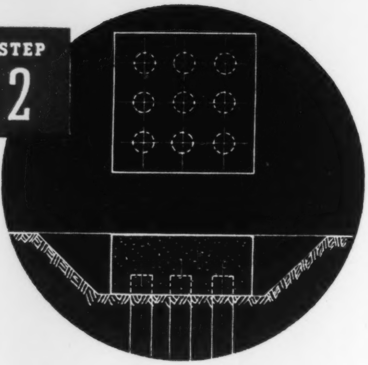
THEW® Lorain

SHOVELS · CRANES · DRAGLINES · CLAMSHELLS · HOES

STEP
1

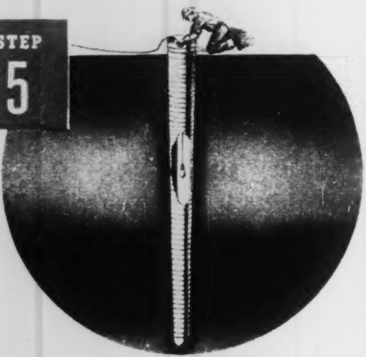
SUBSOIL INVESTIGATIONS... Raymond's exploratory soil borings provide engineers with reliable data for determining the best and most economical foundation design.

STEP
2



SPECIALIZED ENGINEERING ASSISTANCE... When requested, Raymond's highly trained and experienced engineering staff helps you to solve your foundation problems.

STEP
5



TIP-TO-TOP INTERNAL INSPECTION . . . After driving, the core is removed and the pile-shell is thoroughly inspected to assure a satisfactory form, free from water, mud or other materials.

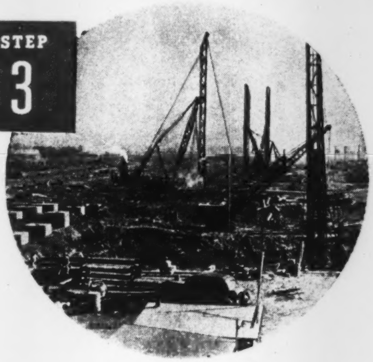
STEP
6

FILLING PILE-SHELLS WITH CONCRETE... Raymond piles are completed by filling the shells with concrete. The shells protect the wet concrete, thereby assuring perfect piles.

8 steps of Raymond service . .

The eight basic steps shown above comprise the Raymond foundation service, which has been advertised in this publication continuously since 1904—a period of 45 years. This record is a measure of our respect for Engineering News-Record, which we heartily congratulate on the occasion of its 75th anniversary.

STEP 3



ASSEMBLING EQUIPMENT . . . The appropriate Raymond-built equipment located nearest the job is quickly assembled. Specialized equipment means efficient service.

STEP 4

DRIVING THE PILE . . . Raymond rigs drive each pile to the specified resistance. Soil pressures developed during driving are fully maintained.

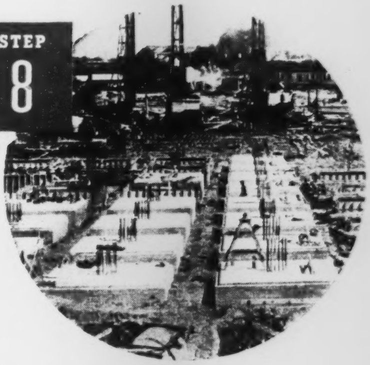
★ ★ ★

STEP 7

240,000# STATIC LOAD TEST
ONE RAYMOND STEP TAPER PIPE PILE
R. R. DONNELLEY AND SONS CO.
ALBERT KAHN ASSOCIATED ARCHITECTS & ENGINEERS
RAYMOND CONCRETE PILE CO. CONTRACTORS
CHICAGO, ILL.

LOAD TESTS . . . When required, the carrying capacity of the pile can be determined by applying a test load to one or more of the piles.

STEP 8



COMPLETED PILE FOUNDATION . . . A Raymond concrete pile foundation is permanent – with bearing capacity uniform and well in excess of specified requirements.

.. advertised 45 years in E.N.R.

SCOPE OF RAYMOND'S ACTIVITIES . . .
includes every recognized type of foundation construction concrete, composite, precast, steel, pipe and wood piles. Also caissons, underpinning, construction involving shore protection, shipbuilding facilities, harbor and river improvements, and borings for soil investigation.

52 YEARS FOUNDED 1897 OF PROGRESS

RAYMOND CONCRETE PILE CO.
140 CEDAR ST • NEW YORK 6, N. Y.

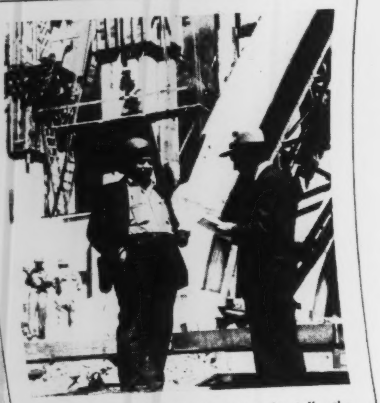
BRANCH OFFICES: Boston, Syracuse, Philadelphia, Baltimore, Washington, Pittsburgh, Atlanta, Miami, Houston, Kansas City, St. Louis, Cleveland, Chicago, Detroit, Portland, San Francisco, Oakland, Los Angeles and principal cities in Latin America.

THE TIGER BRAND SPECIALIST VISITS THE PENN-LINCOLN PARKWAY

and learns a trick or two about wire rope care

"I stopped to see Charlie Dinardo the other day. He's in charge of Dinardo, Inc.'s job of building the 980-foot concrete arch bridge over Nine Mile Run in the Penn-Lincoln Parkway project at Pittsburgh. It's one of the biggest concrete arch jobs in the country in recent years.

"About 15,000 yards of ready-mixed concrete go into this bridge, and 98% of it is being poured by cranes--all equipped with Tiger Brand Wire Rope. They were pouring about 250 yards a day, using a one-yard bucket on a crane equipped with a 105-foot boom and 18-foot jib. In addition to the pouring, the four cranes have handled all steel erection and form setting on the bridge. A job like this really puts rope to a test!



SUPERINTENDENT Charlie Dinardo tells the Tiger Brand Specialist how he obtains maximum life from his Tiger Brand Wire Rope on this rugged job.

"Charlie says he is getting plenty of service from his Tiger Brand Rope. It holds up for three months' steady work on the hoist, and he hasn't replaced a boom rope in over a year.

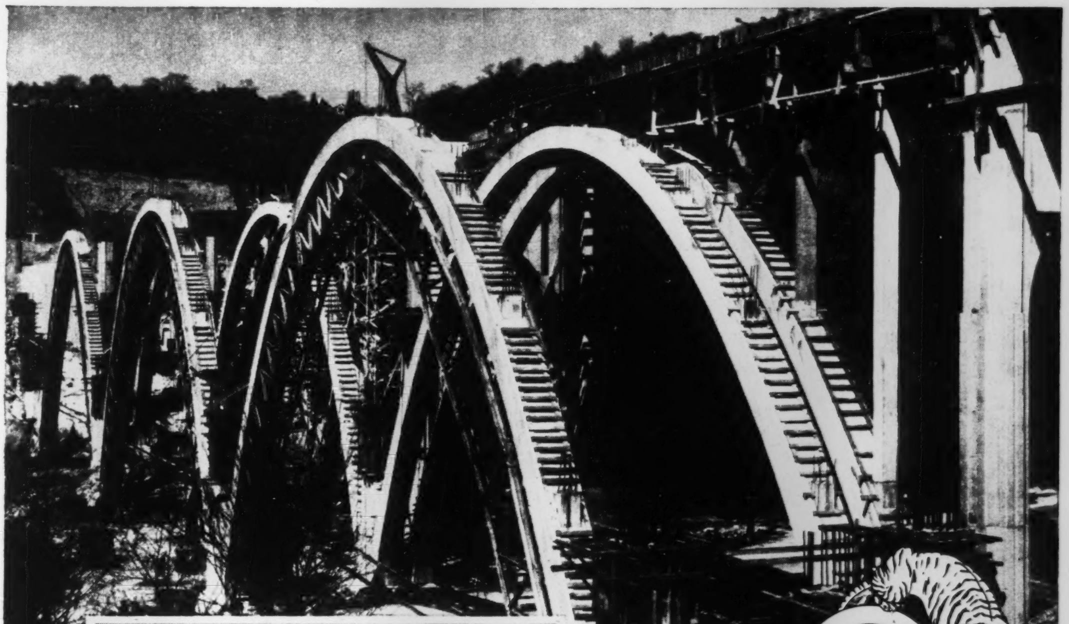
"Charlie passed on a couple of tips on how he gets this kind of service on such a rugged job. First, he uses nothing but Tiger Brand. Second, he observes extra precautions during installation, being especially careful not to introduce any twist into the rope.

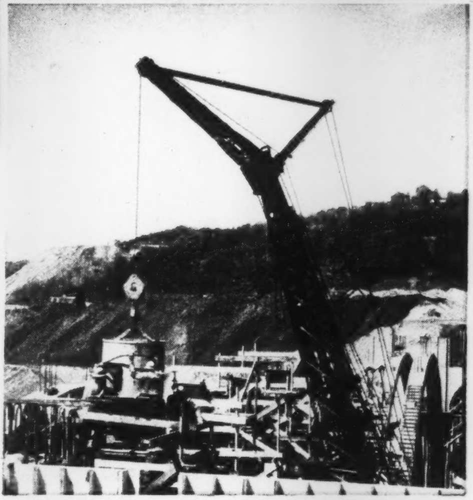
"That's this veteran contractor's method of obtaining exceptionally long rope life. I'm glad to pass it along to you."

ARE YOU GETTING THE MOST FROM YOUR WIRE ROPE?

The TIGER BRAND Specialist—an experienced field service engineer—draws on his own experience and that of veteran construction men like Charlie Dinardo to help you get the best performance from your wire rope at the lowest possible cost.

He'll be glad to talk over your problems with you and make suggestions. Meanwhile, write for our booklet "Valuable Facts About the Use and Care of Wire Rope." You'll find it helpful.





980 FEET LONG . . . 100 feet high at the lowest point in the valley . . . this three span concrete arch bridge carries the new Penn-Lincoln Parkway west toward the Squirrel Hill Tunnels in Pittsburgh, Pa. Dinardo, Inc., Pittsburgh, is the contractor.

98% OF THE CONCRETE in this job is being poured by cranes—equipped with Tiger Brand Wire Rope.

SEND FOR THIS BOOKLET

Valuable Facts

American Steel & Wire Company
Rockefeller Bldg., Dept. A-7
Cleveland 13, Ohio

Gentlemen:

Please send me a copy of your booklet, "Valuable Facts about the Use and Care of Wire Rope."

Name ....

Company ....

Position ....

Address ....

City .... State ....

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA STEEL COMPANY, SAN FRANCISCO
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM, SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

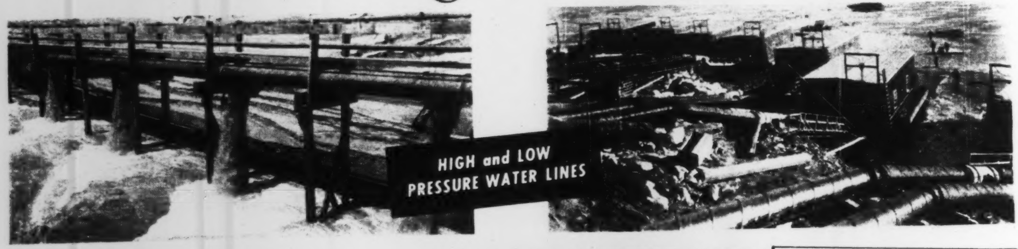
USS

AMERICAN TIGER BRAND WIRE ROPE

Excellay Preformed

UNITED STATES STEEL

FOR JOBS LIKE THESE You'll Do Better With NAYLOR Light-Weight PIPE


HIGH and LOW PRESSURE WATER LINES

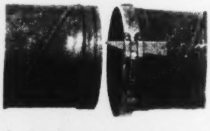
DREDGING LINES

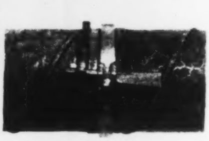
HIGH and LOW PRESSURE AIR LINES

VENTILATING LINES

You'll do better with Naylor Wedge-Lock Couplings, too!

1. A one-piece coupling with gasket in place, easily opened by wedge.


2. Coupling slips over pipe end.


3. Coupling snaps into place over grooved ends of pipe when wedge is removed.

4. Wedge holds coupling leaktight. A hammer is only tool required. Nothing so simple and so fast to connect or disconnect pipe.

Naylor is the one light-weight pipe built to take the tough service required on construction jobs. Its exclusive Lockseam Spiralweld provides extra strength, greater safety, leaktightness and easier handling. Combined with the Naylor Wedge-Lock Coupling, Naylor Pipe is the practical answer for your piping needs. Sizes from 4" to 30" in diameter—thicknesses from 14 to 8 gauge. Write for Catalog 44 or send specifications for quotation.

NAYLOR PIPE COMPANY 1248 East 92nd Street, Chicago 19, Illinois • New York Office: 350 Madison Avenue, New York 17, N. Y.

Something New!

(and better) in DIESELS

P&H DIESEL ENGINES

Model 387-C. 3 cylinder — 2 cycle.

Model 687-C. 6 cylinder — 2 cycle.

◆ The cylinder head and liner assemblies in P&H Diesels are independent — *removable as a unit* — interchangeable on all models.

This P&H patented feature, exclusive in the field of diesel engines, simplifies maintenance problems and reduces servicing time to a new low.

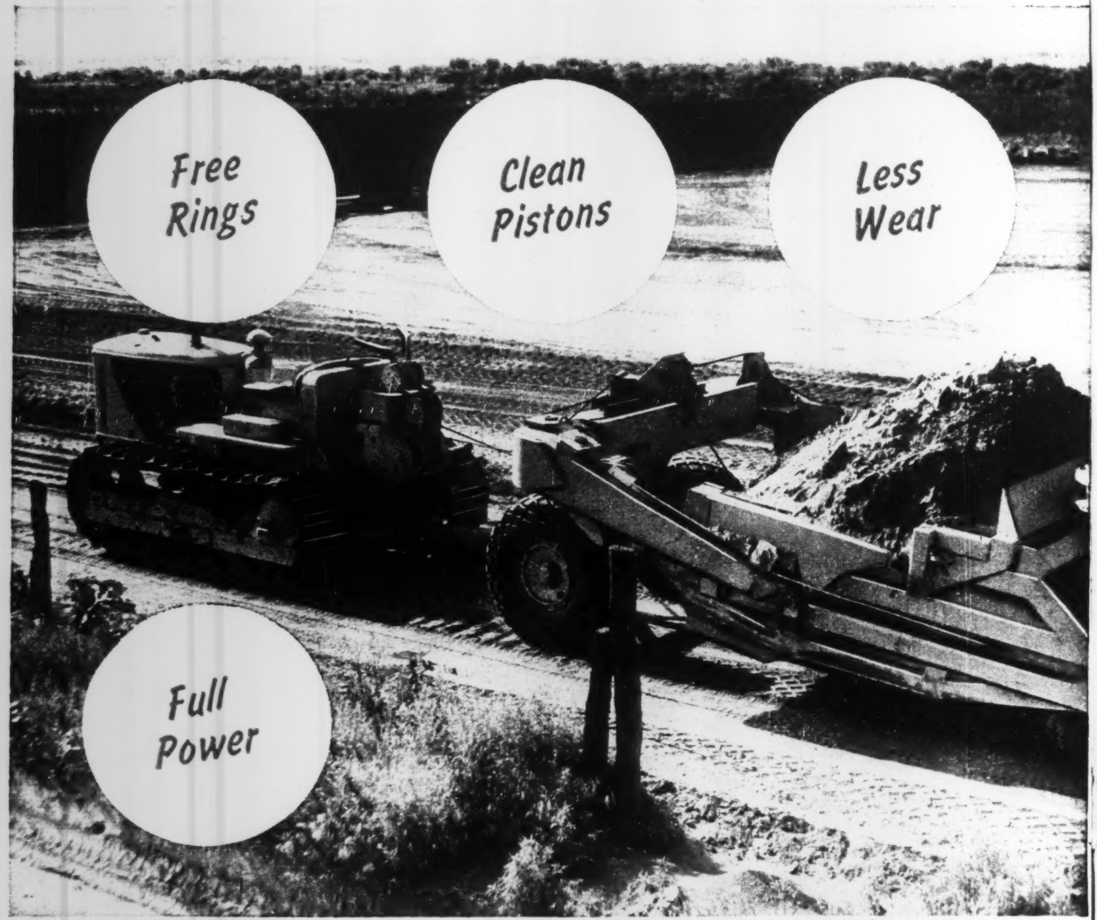
Improved Liner Construction

Longer cylinder life is provided with liners of alloy steel, *hardened* for maximum resistance to wear. Air inlet parts, machined on a compound angle, impart a strong spiral motion which promotes thorough scavenging and assures complete combustion.

Literature on request. Address Harnischfeger Corporation, Diesel Division, Port Washington, Wis.

P&H DIESEL DIVISION
HARNISCHFEGER
EXCAVATORS • ELECTRIC CRANES • ARC WELDERS • P&H • HOISTS • WELDING ELECTRODES • MOTORS

NOW 3 in the SINCLAIR
to meet every


Free Rings
Clean Pistons
Less Wear
Full Power

SINCLAIR

YOUR NEAREST SUPPLIER OF SINCLAIR PRODUCTS WILL GLADLY ARRANGE

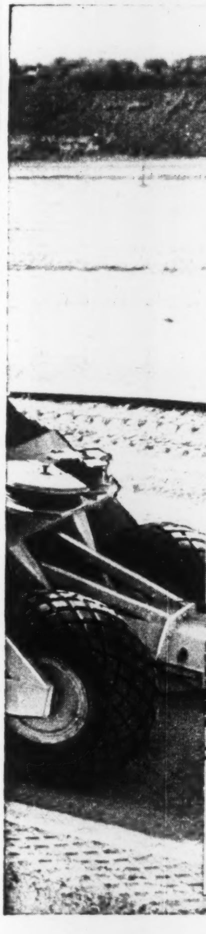
TENOL FAMILY operating requirement

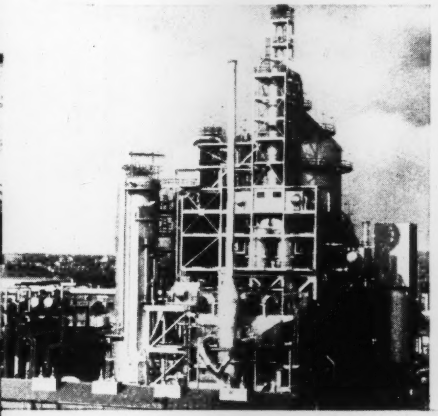
Two new Tenols now make it possible to meet every operating requirement with one of these superior oils. New—SUPER TENOL and TENOL EXTRA are designed to take care of new conditions and "heavier" duty service to which engines are being subjected.

SUPER TENOL meets the engine test requirements of U.S. Army Spec. 2-104 B, Supplemental List 1. It accepts the challenge of continuous, *extra*-hard service and also thwarts cold engine sludge caused in diesels and gasoline engines by long idle and stop-and-go operation. It helps solve the problems caused by the use of improper or high sulphur fuels.

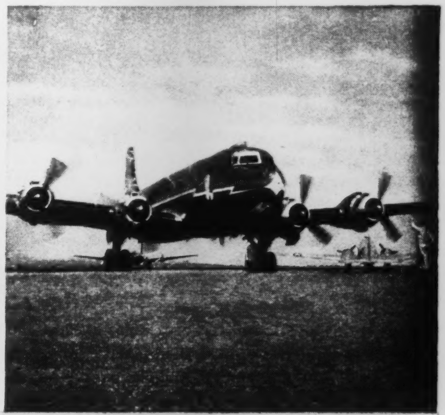
TENOL EXTRA qualifies under U.S. Army Spec. 2-104 B, Supplemental List 2 —and the requirements of Caterpillar Series 2 oil for supercharged diesels, abnormally heavy duty operation and high sulphur fuel.

Use TENOLS as maintenance tools to extend overhaul intervals, engine life.





New Fluid Catalytic Cracking Stills (like the one shown here) are helping to expand Sinclair's refinery output. Sinclair's great refineries are now turning out products at the rate of 150,000,000 gallons of lubricating oil yearly.

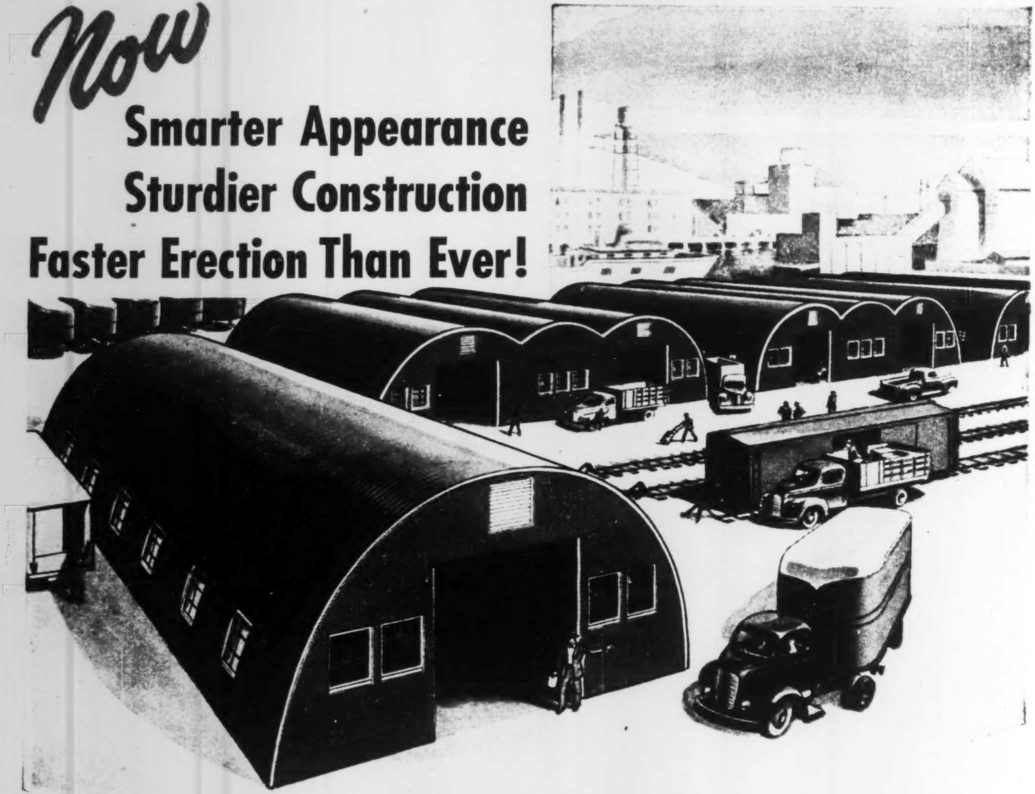


About 40% of all the Aircraft Engine Oil used by domestic Airlines in the U.S.A. is supplied by SINCLAIR. The same careful research that developed this high quality oil for the Airlines is put into TENOL and other Sinclair Oils.

HEAVY DUTY LUBRICANTS

FOR LUBRICATION COUNSEL, OR YOU MAY WRITE TO SINCLAIR REFINING COMPANY, 630 FIFTH AVE., NEW YORK 20, N. Y.

Now
Smarter Appearance
Sturdier Construction
Faster Erection Than Ever!



NEW STRAN-STEEL QUONSETS

Here are all the famed Quonset advantages at their very best—plus developments in styling and construction that make the "world's most useful building" a better value than ever. From slab to crown, these new Quonsets are really *improved* buildings!

There's a clean-lined, modern beauty to the horizontal pattern of the sidewalls. There's just the right touch of contrast in the vertical pattern of the new Quonset crown roof. Architecturally, the new Quonsets are keyed to today.

And appearance is only one of the new Quonset advancements. A more efficient method of bridging and bracing endows the Quonset with even greater structural rigidity . . . makes it stronger and more durable than ever. Specially developed Quonset windows afford added protection against weather.

These new Quonsets go up faster, too. Important design changes simplify erection . . . reduce construction time by more than 25%. This means you'll be in business sooner—you'll make money sooner when you choose the new Stran-Steel Quonsets to meet your building needs. Find out about the new Quonsets from your Quonset dealer today!

STRAN-STEEL AND QUONSET REG. U.S. PAT. OFF.

GREAT LAKES STEEL CORPORATION

Stran-Steel Division • Dept. 59 • Penobscot Building
Detroit 26, Michigan
UNIT OF NATIONAL STEEL CORPORATION

YOU NAIL TO
STRAN STEEL
FRAMING

trademarks of distinction!

TOUSEY
PRODUCTS
DURACOTE for DURABILITY

Good equipment deserves a good finish, and we are proud that these manufacturers have chosen a Tousey finish to protect their products.

TOUSEY VARNISH CO., 520 W. 25TH ST., CHICAGO 16, ILLINOIS

TOUSEY
PRODUCTS
DURACOTE for DURABILITY

WE SALUTE . .

■ To Engineering News-Record . . . and to the engineering profession . . . who, hand-in-hand for 75 years have blazed the trail to a greater America . . . we extend salutations. A salute to the engineering profession whose achievements over the past three-quarters of a century have been spread upon its pages to serve as a stimulus to further progress. A special salute to the trailblazers in the field of water, sewerage and gas service . . . the consulting engineers . . . to whose pioneering ideas the pages of Engineering News-Record have ever been hospitable.

To review some of the landmarks in 75 years of progress in the water, sewerage and gas fields, so largely served by cast iron pipe:

In 1874

there were no water purification plants. **Today, water is processed by over 5,000 of the more than 12,000 public water supply systems serving 85-million Americans;**

there were no sewage treatment plants. **Today, more than 6,000 sewage treatment plants serve over half our urban population;**

there were no natural gas transmission lines. **Today, over 200,000 miles of pipe lines transport natural gas from the fields to cities, towns and villages where the gas is distributed through thousands of miles of cast iron pipe.**

A GREAT PUBLICATION AND THE ...ENGINEERING PROFESSION IT SERVES

To the development of these utility services, so indispensable to urban living, the cast iron pressure pipe industry has contributed from the earliest days. In fact, 210 years before Engineering News-Record was founded, a cast iron water main was installed in Versailles, France, which is still in service. A cast iron gas main laid in Baltimore 115 years ago, and a cast iron water main laid in Philadelphia 127 years ago, are also still in service.

Today, the cast iron pressure pipe industry with its modern casting processes, is better prepared than ever to do its part in meeting the challenge of a greater America. The nation is faced right now with two specific challenges.

Congress has approved a vast public housing construction program. Anti-pollution legislation recently enacted requires the decontamination, or otherwise harmless disposal, of domestic and industrial wastes. Meeting these challenges will call for all the ingenuity and resourcefulness of the engineering profession. It will also require large quantities of cast iron pipe and fittings. We are confident that these challenges will be met and confident also that our industry will contribute to the full extent required. Cast Iron Pipe Research Association, T. F. Wolfe, Engineer, Peoples Gas Bldg., Chicago 3.

CAST IRON PIPE RESEARCH ASSOCIATION

Contributing through research and educational publicity to efficiency and economy in underground transportation of water and gas and sewage

CAST IRON

You Hear It At The Face And In The Front Office

"ROCKMASTER "16" is the greatest improvement in blasting methods since ATLAS introduced milli-second blasting!"

In underground workings, pits, quarries, and construction jobs you hear a lot of enthusiastic talk from men and management about the advantages of the Rockmaster "16" Blasting System.

For example, blasting men at the face talk about better breakage, savings in dynamite, better control of throw, quicker return to the face. And mining men talk about a safer roof—the result of the lack of vibration typical of Rockmaster "16" shooting. When this talk finds its way to the front office, it is quickly translated into greater safety for workers, less expensive handling and milling of rock, less degradation of coal, better rock-production at less cost.

Blasters everywhere—underground and on the surface—find that Rockmaster "16" helps them produce more material per pound of explosive. *Sixteen* periods—a wide choice of short or long milli-second delays—add up to better control over throw, back-break, and material size. And underground, *sixteen* delay periods firing in 550 milli-seconds mean less dust and a quicker return to the face . . . less strain on timbers and roof.

Ask your Atlas representative for the new Rockmaster booklet explaining how Rockmaster "16" fits into your operations.

ROCKMASTER Reg. U. S. Pat. Off.

ROCKMASTER "16" TIMINGS

Rockmaster No.	Avg. Time of Each Delay from Zero (milli-seconds)
0 (zero)	0 (inst.)
1	8
2	25
3	50
4	75
5	100
6	125
7	150
8	175
9	200
10	250
11	300
12	350
13	400
14	450
15	500
16	550

ATLAS EXPLOSIVES

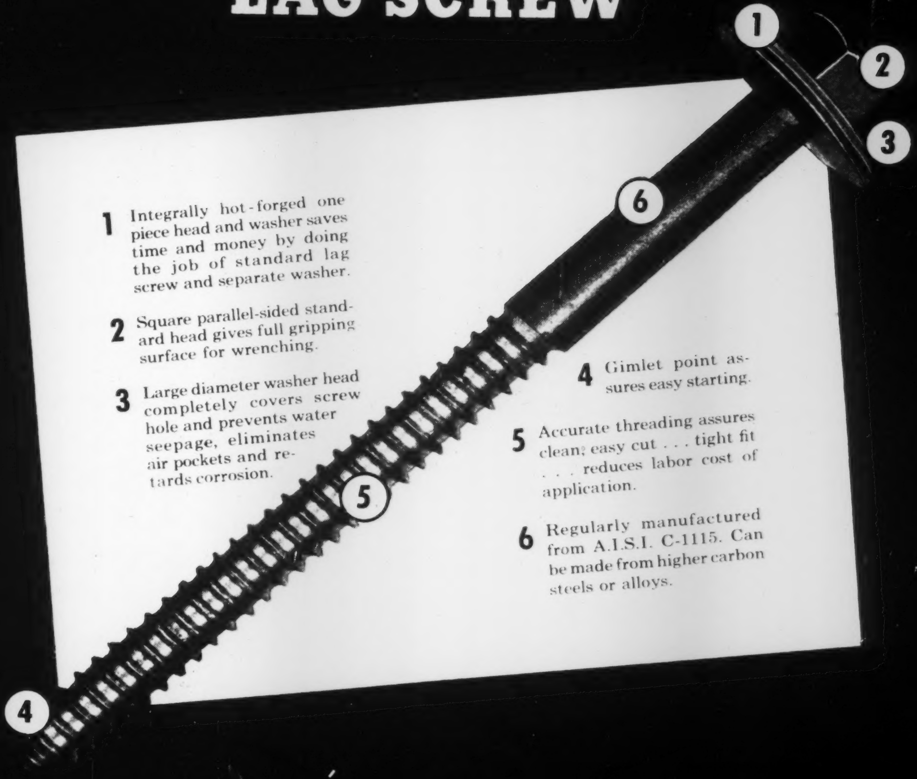
"Everything for Blasting"

CHEMICALS ATLAS EXPLOSIVES

ATLAS POWDER COMPANY, Wilmington 99, Del. • *Offices in principal cities* • *Cable Address—Atpowco*

SEALTITE

LAG SCREW



1 Integrally hot-forged one piece head and washer saves time and money by doing the job of standard lag screw and separate washer.

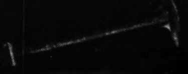
2 Square parallel-sided standard head gives full gripping surface for wrenching.

3 Large diameter washer head completely covers screw hole and prevents water seepage, eliminates air pockets and retards corrosion.

4 Gimlet point assures easy starting.

5 Accurate threading assures clean; easy cut . . . tight fit . . . reduces labor cost of application.

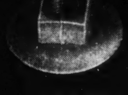
6 Regularly manufactured from A.I.S.I. C-1115. Can be made from higher carbon steels or alloys.



SEALTITE DOMEHEADED BOLT

SEALTITE HOOK BOLT

SEALTITE TIMBER BOLT



SEALTITE WASHER NUT

LOCKTITE NUT

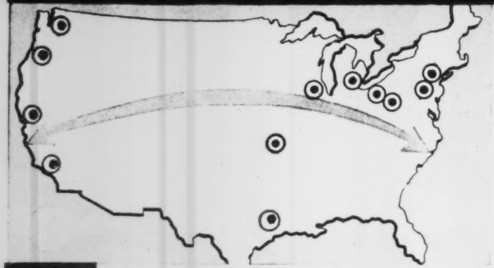
N&W RY
PRECISION TRANSPORTATION

LEWIS BOLT & NUT COMPANY
504 Malcolm Ave. S. E., Minneapolis 14, Minn.

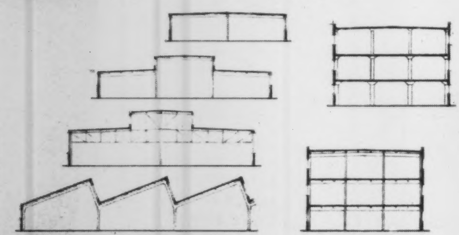
Please send my FREE copy of the new 1949 Catalog.

Company Name
Address
City State
Attention

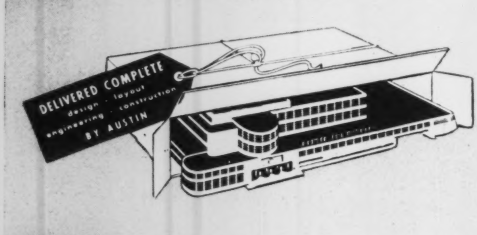
A few historical highlights from



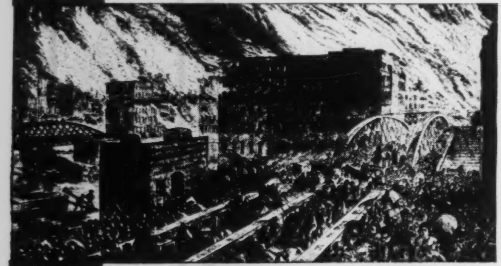
1921 Austin had established permanent offices on the West Coast and in the Southwest to provide a nation-wide, yet localized service.



[illegible] Basic, standardized designs for one story and multi-story buildings were offered for greater economy, flexibility of layout, speed in erection.



[illegible] Introduced the Austin Method of Undivided Responsibility, whereby one organization co-ordinated design and construction under a single contract.



[illegible] On his way to America to help rebuild Chicago after the Great Fire, Samuel Austin, a carpenter, stopped in Cleveland, remained, and founded the firm.

1925 Austin pioneered in the development and adoption of Welded Steel Construction. In 1925, tested electrically welded versus riveted trusses to destruction.

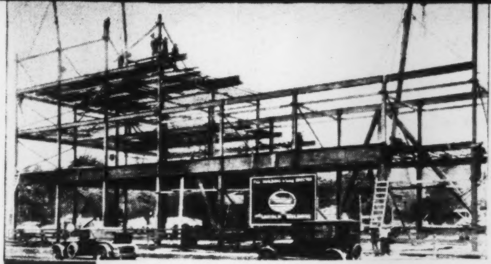
New Research Center of the Sinclair Refining Company, Harvey, Illinois.

TODAY Austin Engineers design and build industrial plants and facilities of practically all kinds and types for a broad range of industries, from textiles to television, from aviation to atomic energy facilities. Austin's complete engineering

THE AUSTIN COMPANY THE AUSTIN METHOD

NEW YORK • PHILADELPHIA • PITTSBURGH
INDIANAPOLIS • ST. LOUIS • HOUSTON • LOS ANGELES

Austin's Engineering Record . . .



1929 Austin designed and erected the first multi-story Welded Steel building on a commercial basis at a cost comparable to riveted construction.

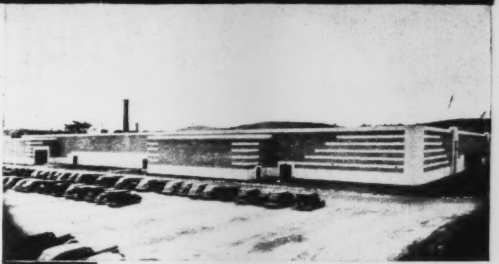
Project located on a 38-acre site, and comprising 9 buildings, was designed and built by Austin.

and construction service is available through a Coast to Coast network of offices, eight of which are completely staffed District organizations.

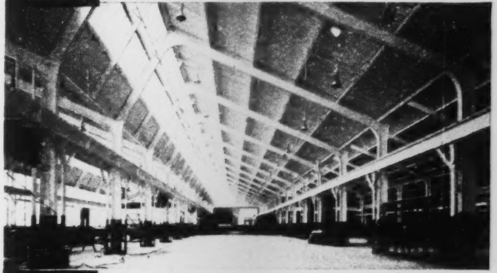
The Austin Method of Undivided Responsibility which combines engineering and construction under a single contract offers definite advantages to an Owner.

ENGINEERS AND BUILDERS • CLEVELAND

WASHINGTON, D. C. • DETROIT • CHICAGO
OAKLAND • PORTLAND • SEATTLE • TORONTO

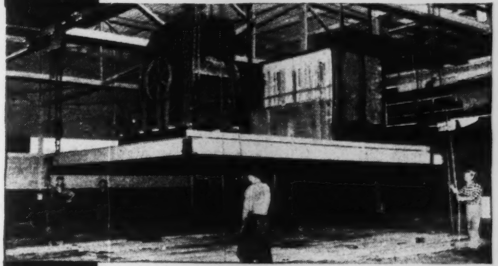


1931 Designed the first "Controlled Conditions" Plant with light, temperature, humidity and noise under control to provide ideal operating conditions.



Offered Rigid Frame Construction to provide better utilization of structural steel, to eliminate shadows and put overhead areas to work.

Developed H-Section Truss to accommodate conveyor, and crane loads more efficiently... strain gage load tests conducted by Case Institute of Technology.

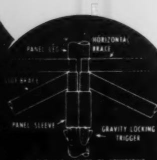


Unit Area System offered to simplify the design, installation and maintenance of air conditioning and electrical load center equipment.

"Up Faster—no bolts to master"

WITH EZEBILT—STEEL-PANEL SCAFFOLDING

More than just a slogan . . . "Up Faster—no bolts to master" tells a story of cost-saving that **must** interest every construction contractor. Fast becoming the standard of the industry, Ezebilt's light tubular steel construction, low cost, adaptability, and fast erection time means payroll dollars saved . . . and more time for more and better jobs.

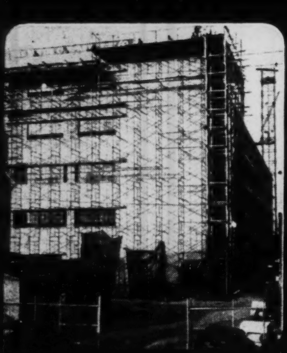


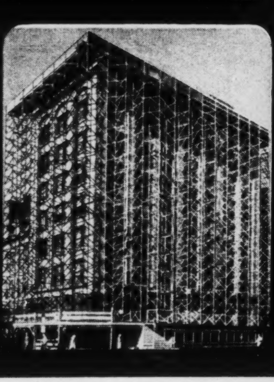
VIEW SHOWING METHOD OF CONNECTING BRACES OR STRINGERS TO PANELS

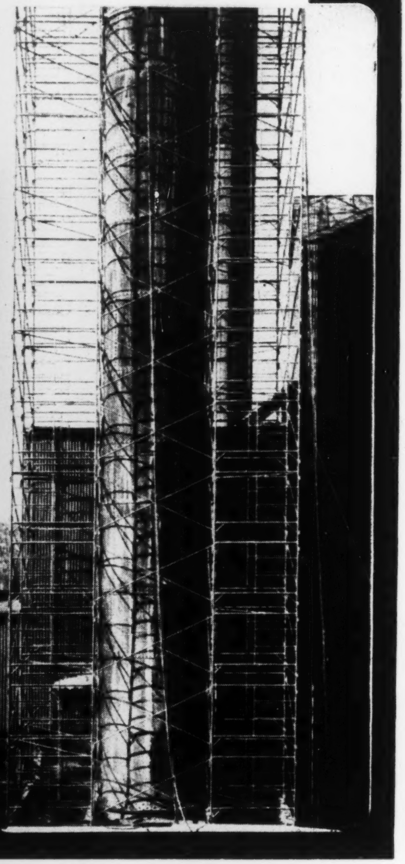
Here's the Magic!

It's Ezebilt's exclusive "Gravity Lock" sleeve arrangement . . . absolutely no bolts, no nuts, no tools for connecting or dismantling.

OWN YOUR OWN—OR RENT—CONSTRUCTION engineers have learned that Ezebilt Steel-Panel Scaffolding soon more than pays for itself, no matter what type of job application. Note in the photographs how adaptable it is for small construction apartment houses, large buildings, or unusually-high scaffolding jobs.







YOUR CONFIDENCE

IS

JUSTIFIED

WHERE THIS FLAG FLIES

ALL TYPES OF CONSTRUCTION, ALL OVER THE WORLD

MERRITT-CHAPMAN
& SCOTT CORPORATION

17 BATTERY PLACE, NEW YORK, N. Y.

FOUNDED IN **1860**

MERRITT-CHAPMAN & SCOTT CORPORATION

Since it first raised its house flag — the Black Horse of the Sea-in 1860, the Merritt-Chapman & Scott Corporation has been building the America of today *and tomorrow.* With confidence our nation has traveled the bridges and tunnels, the highways and airstrips built by this organization and has been served and protected by the waterworks, utilities, and hospitals it has erected. America has benefitted from the products of the mills and factories built by Merritt-Chapman & Scott.

Today this organization, confident through achievement, is eighty-nine years young. Its energy, its skill and its resources are at the service of America.

If your part in America's future embraces construction, examine the abilities of Merritt-Chapman & Scott to translate your plans into reality.

The Merritt-Chapman & Scott Corporation occupies a unique place in the construction industry because of the versatility of its operations. As the following pages show by word and picture, its jobs range from the construction of lighthouses, jetties and piers to the building of complex chemical plants.

Construction activities of the corporation are accomplished by two divisions working in close cooperation to provide clients with the maximum in economy.

For the industrialist, Merritt-Chapman & Scott constructs all types of manufacturing plants. Work done ranges from minor additions and improvements, to vast plants complete with housing developments, public works, and rail, highway, or harbor terminals and facilities.

The Organization performs all foundation, building, mechanical, electrical, and piping work in industrial construction with its own forces. It will, when called upon, undertake the purchasing, expediting, and installation of all equipment. Such "turn key" jobs, complete from foundation to roof, costing many millions of dollars, have been carried out by Merritt-Chapman & Scott.

Paper mills, chemical plants, steel mills, railroad engine repair shops, tank farms, liquid petroleum gas plants, power houses, boiler plants, warehouses, and public buildings are among the achievements of this corporation.

Office buildings, hospitals, and housing projects also are within the experience and ability of the corporation. Contracts for such structures, aggregating more than thirty-five million dollars, are currently in progress and the Organization brings to this work decades of experience in the coordination of men and materials. They are equipped to handle an unusually large proportion of such building construction work with their own forces.

The other major division of this corporation's construction organization is . . . .

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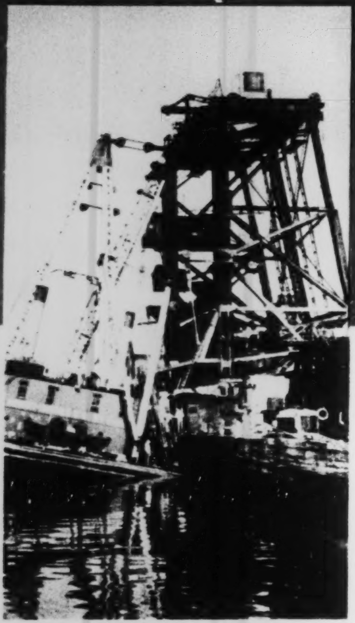
WHERE THIS FLAG FLIES



MARINE AND HEAVY CONSTRUCTION

Plant and experience are evident in the adjoining photographs. The great capacity of the derrick MONARCH, depicted on the left, made it possible to raise the entire coal dumper and saved its dismantling and re-erection to greater height desired. The floating of a mammoth caisson to its position on the site of the Potomac River Bridge is depicted in the facing picture.

. . . . *MARINE AND HEAVY CONSTRUCTION*

Bridges, tunnels, piers, breakwaters, boardwalks, shipways, marine railways, sewage disposal plants and outfalls, lighthouses, shore and coast protection, seawalls, waterworks, bulkheads, harbor improvements, cable laying, dredging, water intakes, marine terminal facilities, dams, locks, subaqueous pipelines, and marine foundations are the routine accomplishments of the Merritt-Chapman & Scott Corporation.

The well established reputation of this organization in this specialized branch of construction is founded on an integration of experienced personnel

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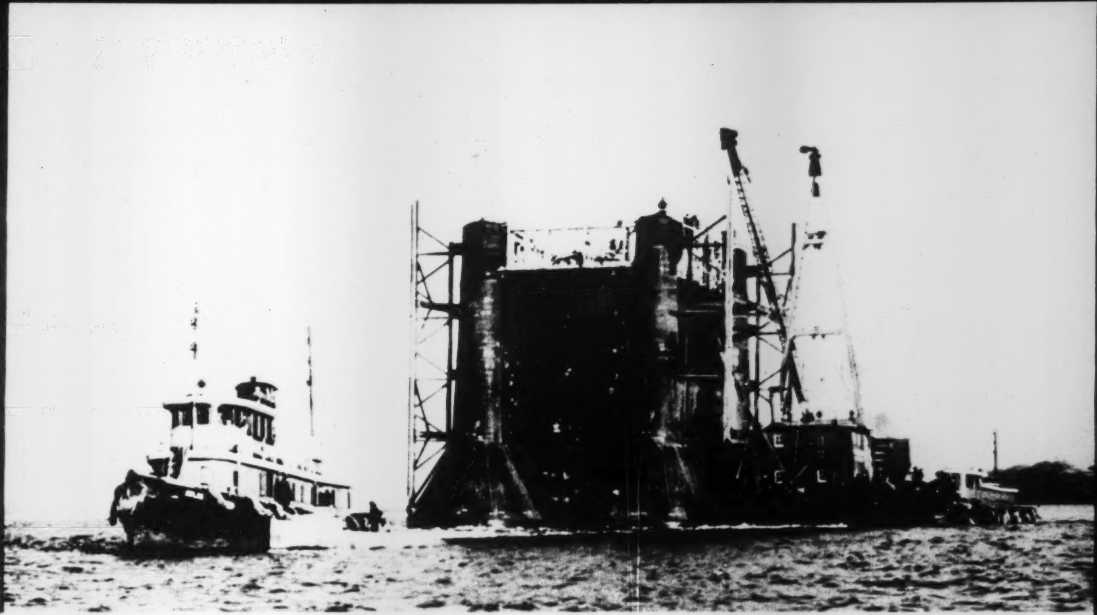


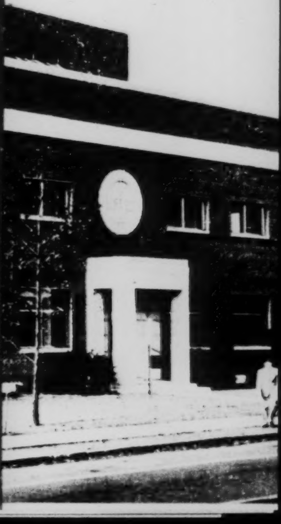
and the finest and most extensive marine equipment available anywhere in the world. This unparalleled combination of experience and plant achieves the utmost in economy of time and money.

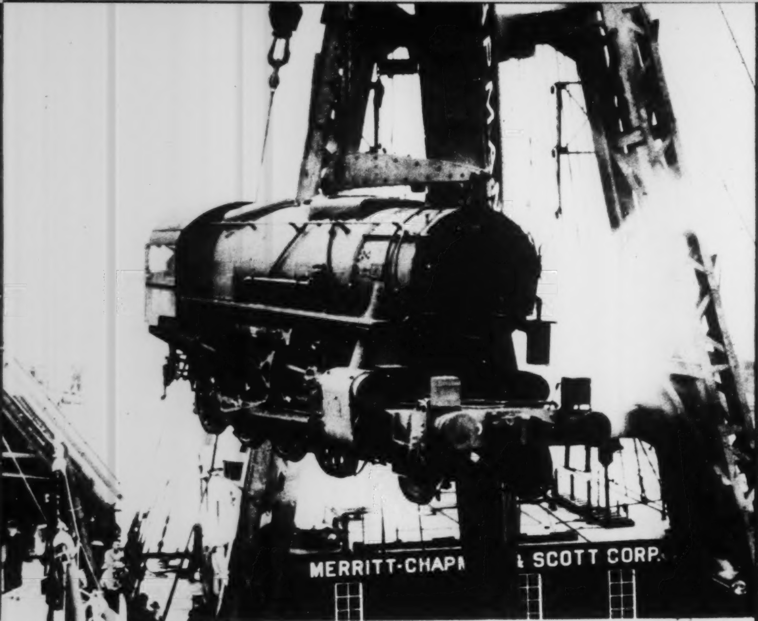
Experience of Merritt-Chapman & Scott in this field stems from 75 years of successful undertakings in the rivers, harbors, and lakes of America.

The floating plant comprises 148 vessels, and includes derricks of up to 250 tons lifting capacity, complete concrete mixing and placing plants, pile drivers, tug boats and scows. Adequately equipped shops and yards for repair of floating and land equipment are maintained at Staten Island, N. Y., Cleveland, Ohio, and New London, Connecticut.

INDUSTRIAL AND BUILDING CONSTRUCTION

"Turn key" jobs of Merritt-Chapman & Scott are well illustrated by the facing photograph of the 200-ton kraft mill and bag factory of the Alabama Pulp & Paper Company at Cantonment, Florida. The project included the construction of all buildings and the purchasing, expediting and installation of all equipment, piping and electrical facilities. Among similar "Turn key" jobs were two streptomycin plants built for Merk & Co.





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WHERE THIS FLAG FLIES

HEAVY HOISTING

— is a specialized business of Merritt-Chapman & Scott in the Port of New York, where 18 floating derricks handle the greater portion of the heavy lifts in those waters, including the hoisting of heavy members of bridges and other waterfront structures. Most of these vessels are documented and adapted for coastwise travel and are a part of the incomparable plant at the disposal of Merritt-Chapman & Scott marine construction clients.

• • • • • • • •

MARINE SALVAGE

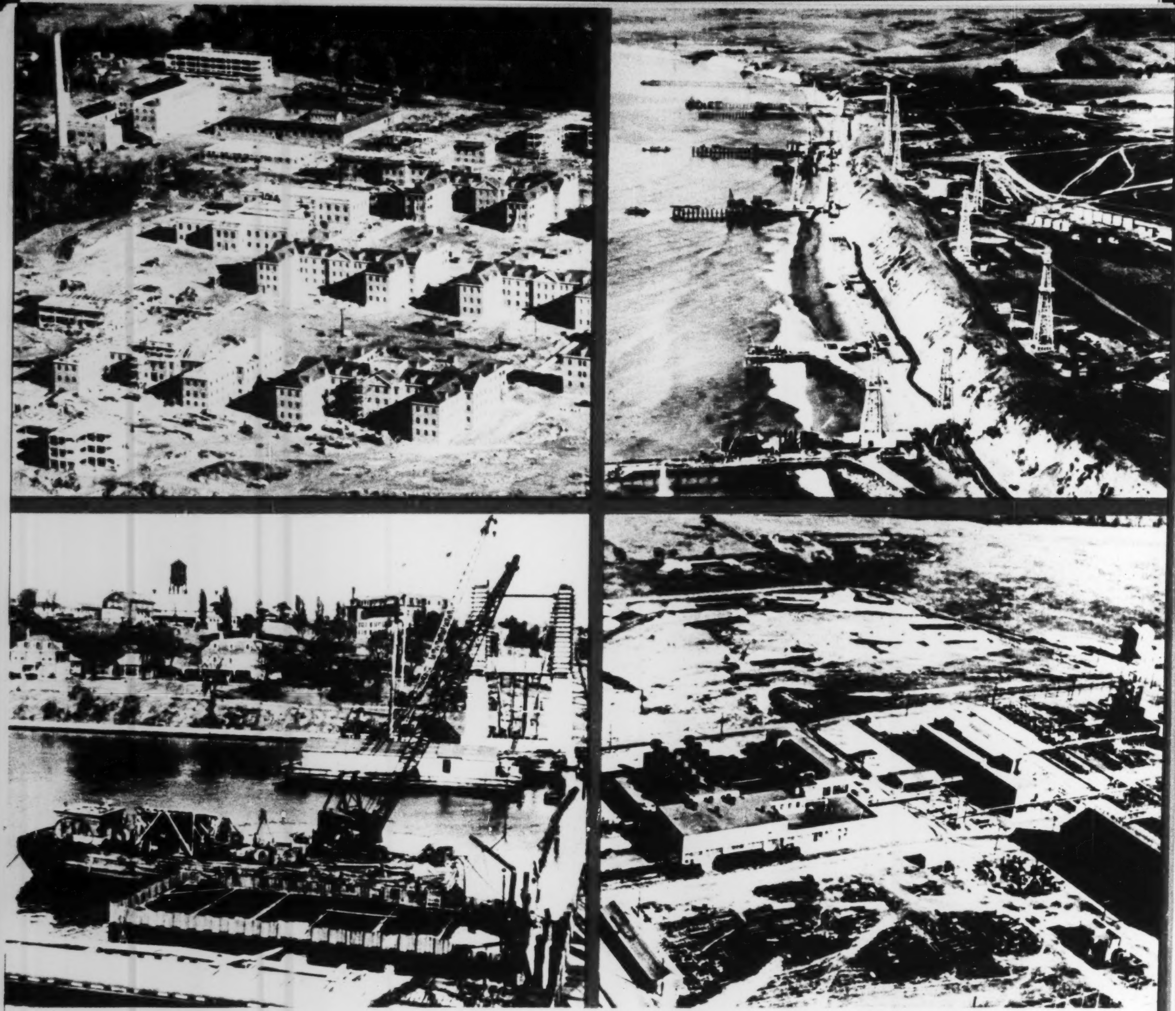
— and the name Merritt-Chapman & Scott are synonymous. The modern salvage vessels, equipment and experienced personnel maintained by the corporation today constitute the only large scale offshore and coastwise salvage facilities available in the Western Hemisphere. Though a far cry from land construction, this leadership is another reflection of the ability of the Merritt-Chapman & Scott organization to succeed in an arduous field.

Confidence....

There is no better evidence of the ability of Merritt-Chapman & Scott Corporation to construct a wide variety of projects with skill, speed and economy than this partial list of outstanding clients it has served:

* * *

- Alabama Pulp & Paper Co.
- Allied Chemical & Dye Corporation
- American Brass Co.
- American Bridge Co.
- American Cyanamid Co.
- American Telephone & Telegraph
- Ansco Co.
- Atlantic Refining Co.
- Ballard Oil Co.
- Baltimore & Ohio Railroad
- Bell Telephone Company of Pennsylvania
- Bethlehem Steel Corp.
- Bridgeport Gas Light Co.
- Buckley Bros. Inc.
- Camp Manufacturing Co.
- Central Hudson Gas & Electric Co.
- Champion Paper & Fibre Co.
- Charles Pfizer & Co., Inc.
- Cities Service Oil Co.
- City of Bayonne
- City of Bridgeport
- City of Los Angeles
- Colonial Beacon Oil Co.
- Connecticut Power Co.
- Consolidated Edison Co., of N. Y.
- Container Corporation of America
- Delaware River Joint Commission of Pa. & N. J.
- Delaware, Lackawanna & Western R. R.
- Dexter Sulphite Pulp & Paper Co.
- District of Columbia Dept. of Highways
- Eastman Kodak Co.
- E. I. DuPont de Nemours & Co.
- Electric Boat Co.
- Elizabethtown Consolidated Gas Co.
- Farrell Lines
- Fire Department of N. Y. C.
- Ford Motor Co.
- General Chemical Co.
- Greenwich Water Co.
- Gulf Oil Corp.
- Hartford Electric Light Co.
- Hudson Pulp & Paper Corp.
- Huron Portland Cement Co.
- Jersey Central Power & Light Co.
- Jones & Laughlin Steel Corp.
- Mystic River Bridge Authority
- National Container Corp.
- National Lead Co.
- National Tube Co.
- New London Terminal Corp.
- Newport Electric Corp.
- New York Central System
- New York City Dept. of Public Works
- New York City Dept. of Marine & Aviation
- New York Water Service
- Pennsylvania R.R.
- Port of Boston Authority
- Providence Gas Co.
- Riegel Paper Co.
- St. Regis Paper Co.
- Seatrain Lines Inc.
- Shell Oil Co.
- Socony Vacuum Oil Co.
- Southern New England Telephone Co.
- Southland Paper Mills Inc.
- Standard Oil Co. of N. J.
- Staten Island Edison Corp.
- Texas Co.
- Tidewater Associated Oil Co.
- Todd Atlantic Shipyards
- Union Bag & Paper Corp.
- U. S. Navy Dept.
- U. S. War Dept.



TO AMERICAN INDUSTRY

Merritt-Chapman & Scott Corporation offers the services of a well-financed, skilled organization with unusually adequate plant facilities, trained personnel, nearly a century of experience and — over and beyond these qualifications — the energy, determination and will to do its share in Building a Greater America.

C. H. COTTER, President

NEW LONDON, CONN. • CLEVELAND, OHIO • KEY WEST, FLA • KINGSTON, B.W.I. • CARACAS, VENEZUELA
BOSTON, MASS. • PASADENA, TEXAS

E. CARTER PERKINS

THE ARUNDEL CORPORATION

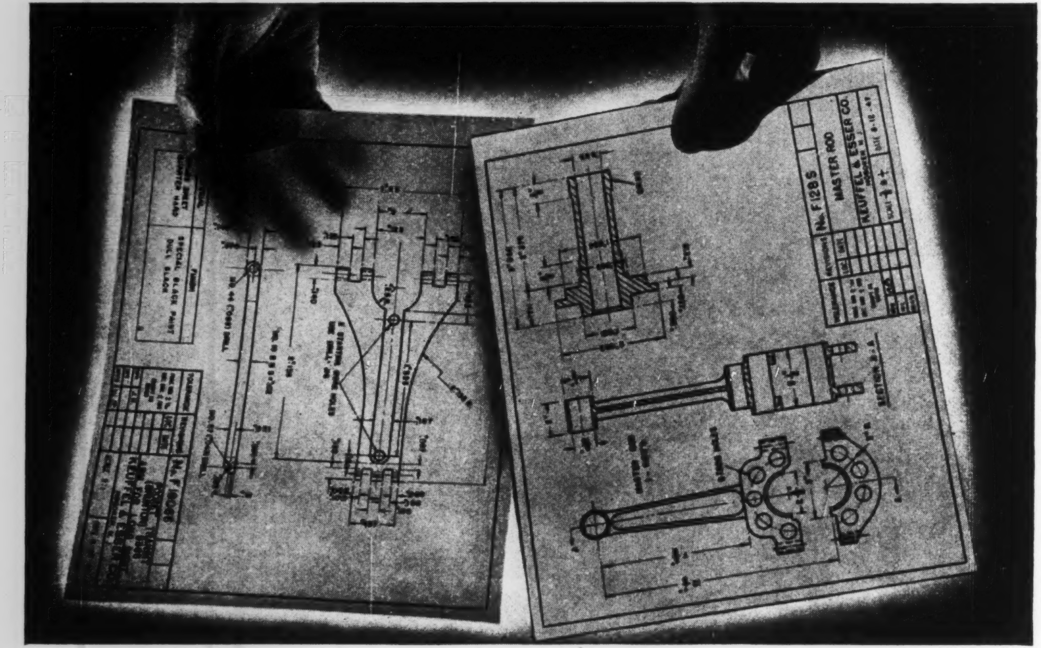
BALTIMORE, MD.

DREDGING • ENGINEERING CONSTRUCTION

Distributors of SAND • GRAVEL • STONE & COMMERCIAL SLAG

K+E partners

For 82 years K&E equipment and materials have been



ONLY HELIOS* DRY DEVELOPING MATERIALS GIVE YOU:

K&E QUALITY. Trusted by draftsmen and engineers for 82 years.

K&E DEPENDABILITY. Your best assurance of consistent results in making positive line prints.

Only when you use dependable materials can you get consistent results in making positive line prints.

To be sure of absolute K&E standards in the color-forming components required for these dry diazo products, we established a new plant where we manufacture HELIOS materials exclusively. We not only control and make the finished materials, but actually manufacture, from the raw materials, the image-forming chemical components as well. Thus HELIOS papers, cloths and films are the product of 82 years of K&E experience and K&E insistence on quality first.

HELIOS dry developed materials cover a wide field of reproduction needs. They consist of opaque papers (black, blue and maroon line) and opaque cloth for working prints, besides transparent papers and cloth and clear and matte films, for intermediate originals (to use instead of originals).

in creating . . .

partners of the draftsman, the engineer and the scientist in shaping the modern world

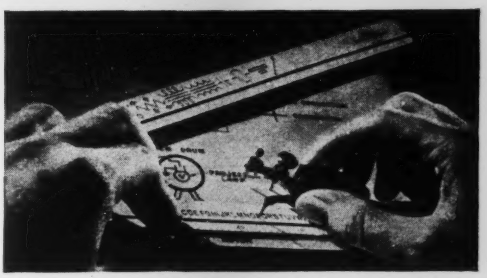
For samples and full information about the HELIOS line and what it can do for you, ask any K&E Dealer or Branch or write us here in Hoboken, N. J.

PARAGON* DRAFTING MACHINES TAKE WASTE MOTION OUT OF DRAWING

The PARAGON Drafting Machine combines T-Square, triangles, protractor and scales, all in one single unit, controlled entirely by one hand. The scales glide into any position on the board. The lightest touch rotates them to the angle desired. You can draw all lines to exact length.

The design of the PARAGON Drafting Machine assures permanent accuracy. The open center arm construction makes it practically impossible to disturb the band tension, which is properly set at the factory and needs no further adjustment.

Let your K&E Dealer or Branch demonstrate this machine or write for full description to Keuffel & Esser Co., Hoboken, N. J.



LEROY* LETTERING AND SYMBOL DRAWING IS UNIFORM AND QUICK

LEROY lettering and symbol drawing need no special skill or training. LEROY equipment offers a wide variety of alphabets and sizes, including Regular Gothic, Reversed, Condensed, Extended and Outline Gothic, Cheltenham, Greek, Isometric alphabets and ellipses, Electrical, Map and Welding symbols.

K&E can make special LEROY templates with your own words, phrases, designs, symbols or trade marks.

Ask your K&E Dealer or any K&E Branch for a demonstration or write to K&E, Hoboken, N. J. for the LEROY Booklet.

*Trade Mark®

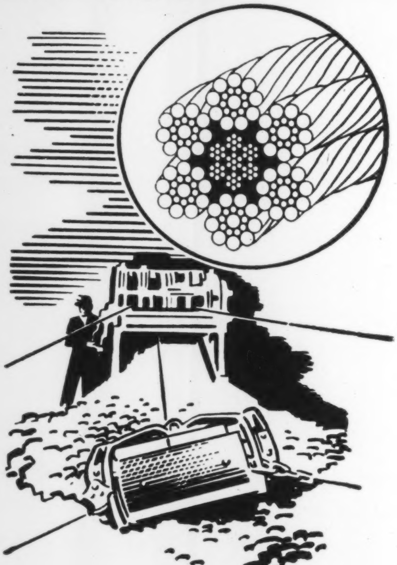
K+E

Drafting, Reproduction,
Surveying Equipment
and Materials.
Slide Rules,
Measuring Tapes.

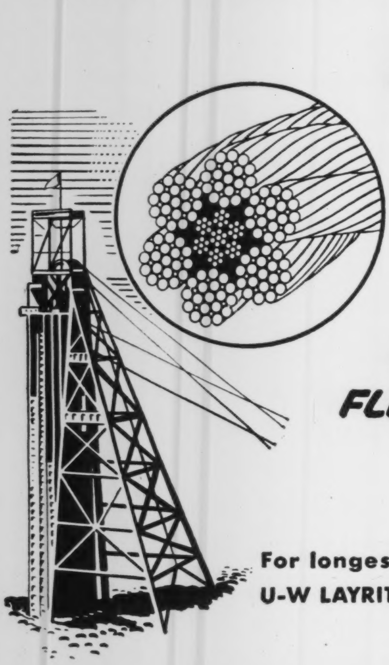
KEUFFEL & ESSER CO.
EST. 1867
NEW YORK • HOBOKEN, N. J.
CHICAGO • ST. LOUIS • DETROIT • SAN FRANCISCO
LOS ANGELES • MONTREAL

SOME ROPES FOOL YOU

U-W 6×19 SEALE IS AN EXCELLENT CONSTRUCTION FOR SLUSHER OR SCRAPER PULL ROPES BECAUSE IT HAS VERY COARSE OUTER WIRES TO RESIST ABRASION



BUT...



FOR MINE SHAFT ROPES U-W 6×19 FILLER WIRE IS BETTER BECAUSE IT IS MORE FLEXIBLE AND RESISTS FATIGUE EXCEPTIONALLY WELL.

For longest and best service, always specify
U-W LAYRITE (*Preformed*) IMPROVED PLOW STEEL

We invite you to let UPSON-WALTON engineer your tough rope jobs.

Copyright 1948—The Upson-Walton Company

THE UPSON-WALTON COMPANY
Manufacturers of Wire Rope, Wire Rope Fittings, Tackle Blocks, Brattice Cloth
Main Offices and Factory: Cleveland 13, Ohio

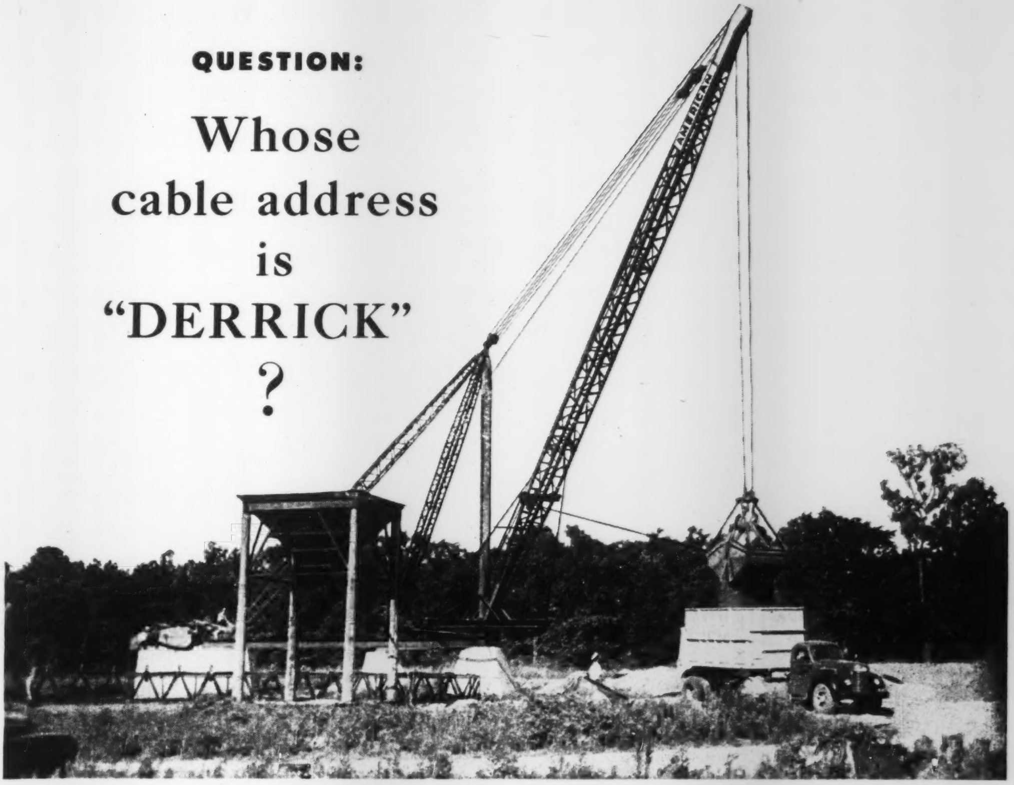
114 Broad Street
New York 4

3525 West Grand Ave.
Chicago 51

241 Oliver Building
Pittsburgh 22

QUESTION:

Whose cable address is "DERRICK"?



From Johannesburg, South Africa or Point Barrow, Alaska . . . from Brisbane, Australia or Copenhagen, Denmark . . . if you want the best possible help in moving materials at lowest cost, just send a cable message with the simple address "DERRICK"!

All over the world, construction men know that "DERRICK" is the cable address of American Hoist and Derrick Company, at St. Paul, Minnesota or South Kearny, New Jersey. And that's an easy way for you, too, to remember that this organization has had more derrick experience than you'll ever need in a lifetime.

What kind of a derrick will you need next? Perhaps a stiff-leg, of the type shown here, for handling loose materials. Perhaps a steel erector. Perhaps something special—a big gallows frame, or gin pole, or a barge derrick. Whatever it may be, you can be sure that American Hoist has built it before, and knows how to build it *right*.

Your inquiry addressed to "DERRICK" brings you quick, intelligent service backed by a large staff of engineering specialists, and the facilities of derrick shops second to none. Our line is the most complete offered anywhere—derricks of all types, all sizes, from 3 to 250 tons capacity. Would you like a general catalog? Just mail the coupon.

ANSWER:

American Hoist
and DERRICK COMPANY
St. Paul 1, Minnesota

Plant No. 2: So. Kearny, N. J.
Sales Offices: NEW YORK • PITTSBURGH • CHICAGO

9201

American Hoist and Derrick Co.
St. Paul 1, Minnesota

Please send catalog on AMERICAN Derricks.

NAME____________________

COMPANY____________________

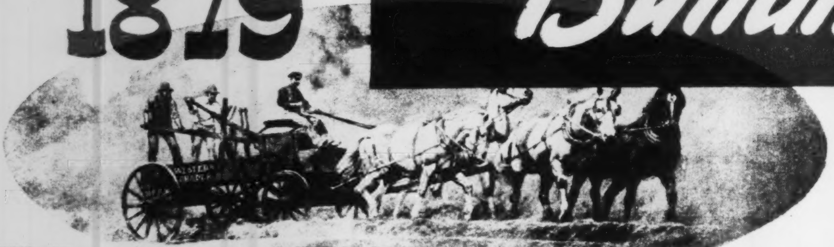
ADDRESS____________________

CITY__________ STATE__________

3

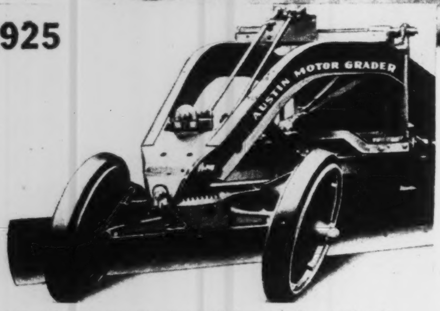
Building a

1879



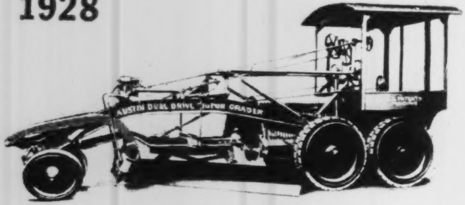
Builder of the world's first road grader in 1879, Austin-Western has pioneered more motor grader features than any other manufacturer, through the years. The motor grader of 1933 was a much better machine than those of the early 20's, but was still almost totally incapable of doing heavy ditching and rough grading. It remained for Austin-Western to take the final step in motor grader design—the all-wheel drive, all-wheel steer "99" Power Grader of 1937, which gave the owner a machine capable of going places where ordinary motor graders couldn't go . . . doing things they couldn't do.

1925



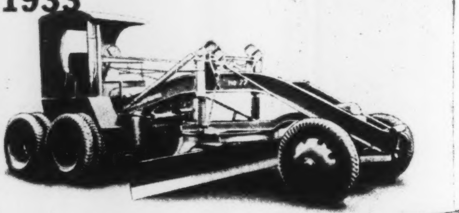
1925—First Motor Grader with leaning front wheels.

1928



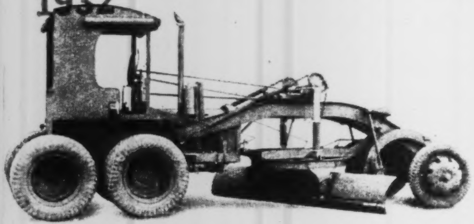
1928—First Motor Grader with dual (tandem) drive.

1933



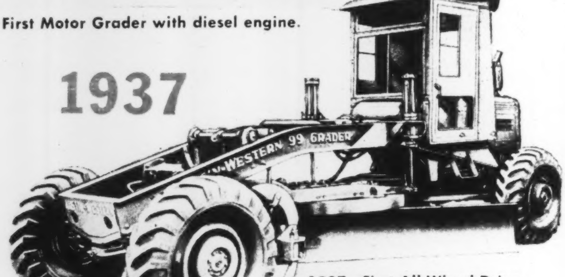
1933—First Motor Grader with diesel engine.

1932



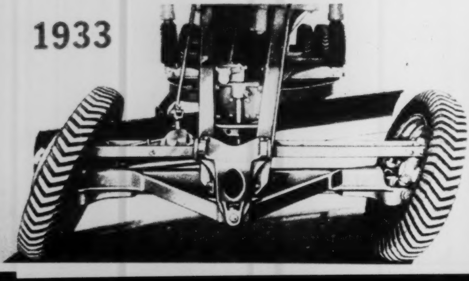
1932—First Motor Grader with hydraulic control.

1937



1937—First All-Wheel Drive, All-Wheel Steer Power Grader.

1933



1933—First Motor Grader with wide front axle.

Motor Grader History is AUSTIN-WESTERN Histor

Greater POWER GRADER

1949

the POWER GRADERS that have Everything

The Austin-Western Power Grader of today owes its matchless performance to *completely effective* use of power. Through All-Wheel Drive, every pound of weight is a powered pound, harnessed to a driving wheel—and contributing every ounce to tractive effort. This tremendous traction—perfectly directed and controlled through All-Wheel Steer—provides superb earth moving ability, and mastery of all types of work. Additional values are offered by specialized attachments, which greatly increase the usefulness and day-in and day-out profit making ability of the graders.

AUSTIN-WESTERN COMPANY, AURORA, ILLINOIS, U.S.A.

"88-H"—a new model which brings to the field of motor graders of medium size the extra traction and power-at-the-blade of all-wheel drive; the unequaled maneuverability of all-wheel steer, and the other exclusive features which have made the "99's" so deservedly popular.

"99-H"—the "old reliable"—out in front of the motor grader parade since the original "99" of 1937. Popular with contractors and highway departments for its all-around performance, under all conditions, in all seasons.

MASTER "99"—another new model, combining all of the time- and money-saving features of the "99-H" with the extra power, traction and road speed of its 100 horsepower engine. Tops in performance and value for those who want the best.

BUILDERS OF ROAD MACHINERY

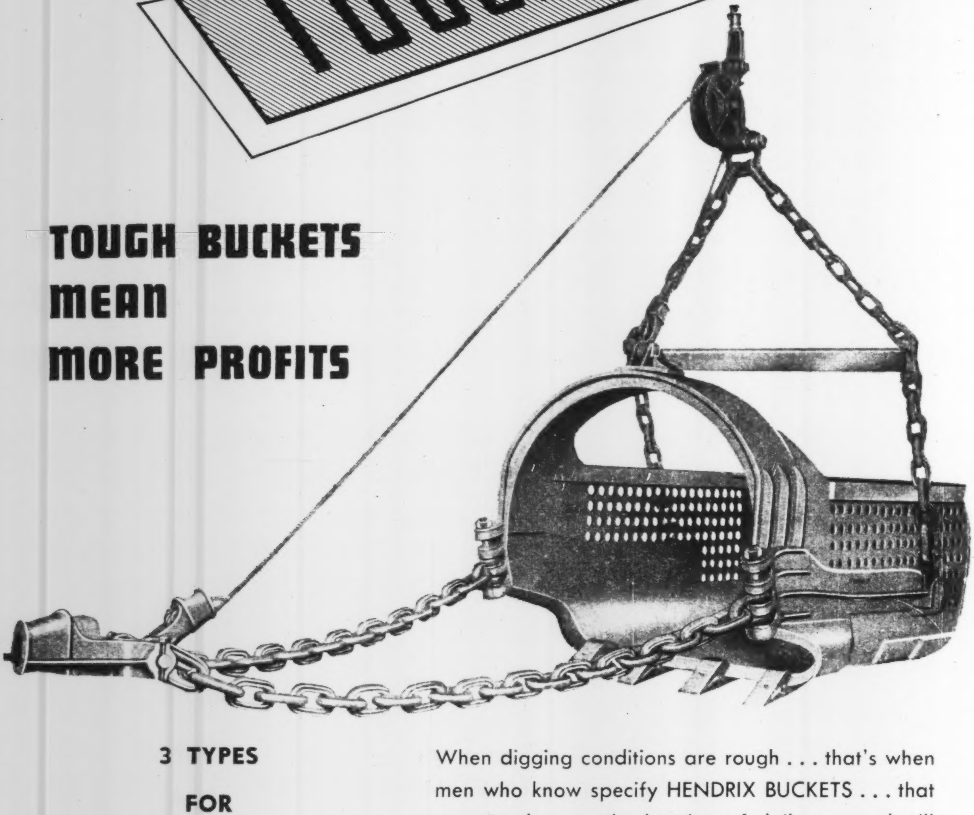
Austin Western

SINCE 1859

Rough Service Needs

TOUGH BUCKETS

**TOUGH BUCKETS
MEAN
MORE PROFITS**



3 TYPES

FOR

EVERY DIGGING PURPOSE

3/8 to 40 Cu. Yds.

When digging conditions are rough . . . that's when men who know specify HENDRIX BUCKETS . . . that can stand up to the beating of daily use and still deliver top production. They're built to take it and built to give you low-cost, maintenance-free performance that means profitable operation.

HENDRIX
Lightweight **DRAGLINE BUCKETS**

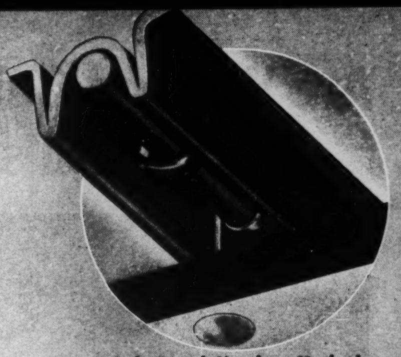
For descriptive literature ask your dealer or write

HENDRIX MANUFACTURING CO., INC.

MANSFIELD — LOUISIANA

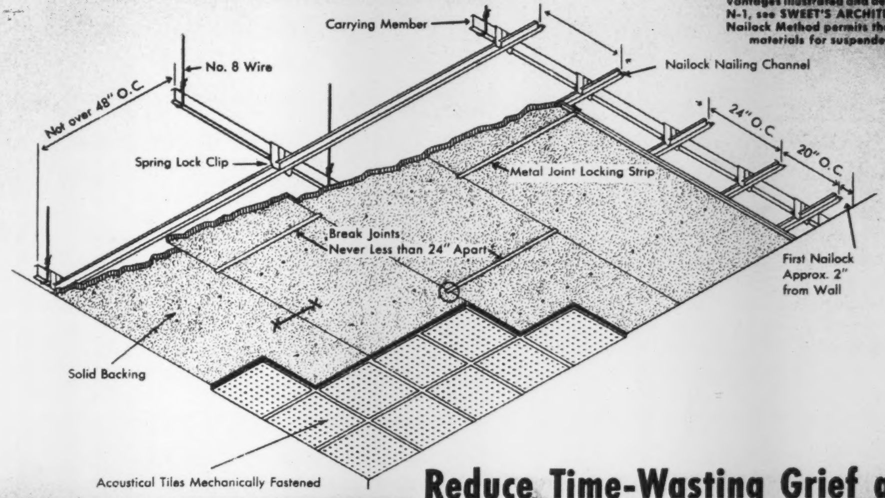
For Suspended Ceiling Construction

Use *Nailock*



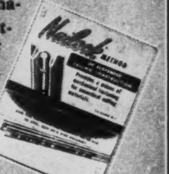
Safest and Simplest Method

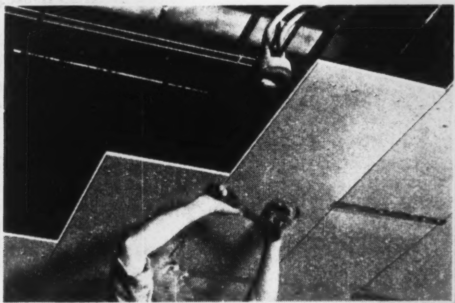
The Nailock Method is the simplest and safest method of installing a suspended ceiling with or without acoustical tiles. This method presents many exclusive advantages illustrated and described in Nailock Catalog N-1, see SWEET'S ARCHITECTURAL FILE, 11b/1. The Nailock Method permits the use of a wide variety of materials for suspended ceiling construction.


Carrying Member
No. 8 Wire
Nailock Nailing Channel
Not over 48" O.C.
24" O.C.
20" O.C.
Spring Lock Clip
Metal Joint Locking Strip
Break Joints Never Less than 24" Apart
First Nailock Approx. 2" from Wall
Solid Backing
Acoustical Tiles Mechanically Fastened

Reduce Time-Wasting Grief and Time Costs on Suspended Ceiling Jobs

- Nailock Universal Nailing Channels provide a means for securely fastening every unit in place, and assure a rigid, safe and permanent suspended ceiling installation. It permits the use of larger crews in making installations in large areas due to the speed with which Nailock Universal Nailing Channels can be attached to carrying members and the simplicity of nailing backing or backerboard materials to these channels. The Nailock Method permits the use of any type of acoustical materials attachable by mechanical means, or by cementing, and all of the usual methods and materials of finishing a ceiling, including plastering. Refer to Nailock Catalog N-1 in SWEET'S 1949 ARCHITECTURAL FILE, 11b/1. Catalog available on request. Please use coupon.


Nailock Method



Permits Use of Any Acoustical Materials Required

Installation with Nailock requires only three operations. This shows nailing solid backing to Nailock Universal Nailing Channel with Nailock Nails which form locking loop around rod. Assures rigidity and permanency and safety.

NAILOCK STEEL DIVISION

THE SANYMETAL PRODUCTS CO., INC.

1704 URBANA ROAD · CLEVELAND 12, OHIO

Nailock Steel Division, The Sanymetal Products Co., Inc.
1704 Urbana Road, Cleveland 12, Ohio

Please send Nailock Catalog N-1 and name of nearest Nailock Distributor.

Name .... *Position* ....
Company ....
Address ....
City .... *State* ....
(Please attach to your business letterhead)

Arc Welding Cuts Construction Costs 20% on World's Largest Harbor Shed

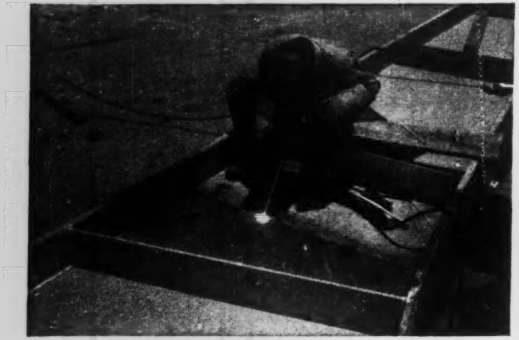


Fig. 1. Field welding truss sections to fabricate 200-foot span rigid frame, using 200-amp. Lincoln "Shield-Arc" Engine Driven Welders. Sections are lined up with a transit and tack welded prior to finish welding.

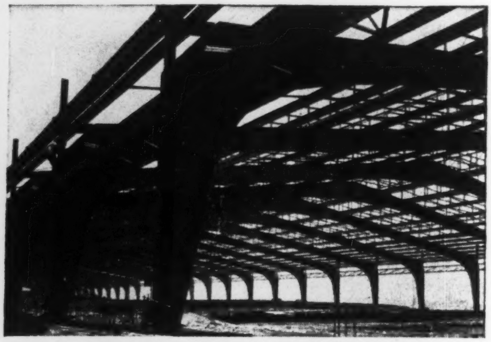


Fig. 2. All welded rigid frame Harbor Shed at Long Beach, California. Designed by R. D. Sandham under direction of R. R. Shoemaker, Chief Engineer, and R. J. Amar, Port Manager. Steel fabricated and erected by Pacific Iron and Steel Company of Los Angeles.

SIMPLER, faster construction made possible by arc welding, accounts for an estimated 20% saving in structural cost of the Harbor Transit Shed at Long Beach, California. Built entirely with arc welding, this 2,625-ton rigid frame structure was erected in only 90 days with a 32-man erection crew. By eliminating rivets and gusset plates, designers cut the structural weight by more than 7%, creating the world's largest unobstructed single span harbor shed—1,200 feet long, with a 200-foot span and 40 feet high.

The 32 rigid frames used were shop fabricated in 30 working days using flame cut steel plate and standard rolled shapes. Seventy per cent of the arc welding was finished in the shop using fast, simple downhand welding techniques. Forty-foot sections thus fabricated were then trucked to the erection site for field welding.

Erecting operations were so planned that the 32-man crew could raise and connect the trusses with the I-beams at a rate of 8 frames in a six-hour shift, an erection speed considered impossible with riveted construction. Three 20-ton cranes raised the field-assembled 50-ton all-welded rigid frames, holding them in position while connecting I-beams and trusses by arc welding with 200-amp. Lincoln "Shield-Arc" Engine Driven Welders.

The unique Long Beach Harbor Transit Shed is built to withstand earthquakes. Each rigid frame rests on a 5-inch diameter hardened pin, thus compensating for any light movement or settling that might occur in the harbor area.

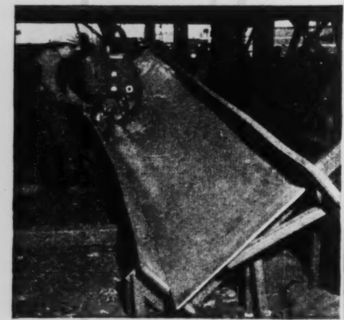


Fig. 3. Shop fabricating truss sections, using "Automatic Lincolnweld." Fillet welds are made in single pass at 600 amps. and speed of 24 inches per minute.

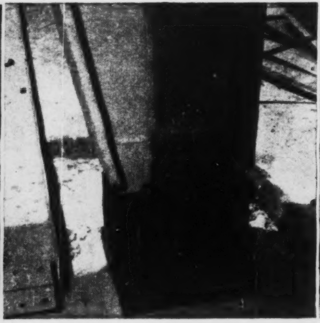


Fig. 4. Hip girder connection to base plate. Five-inch diameter horizontal pin allows free movement in case of earthquake or settling in harbor area.

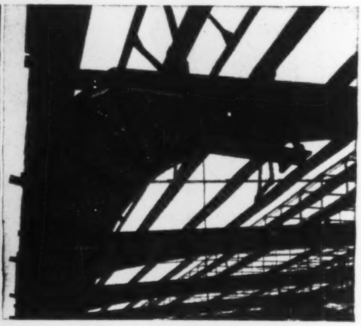


Fig. 5. Welding truss to hip girder. Butt joints are completed with ten passes on flange plate and two passes on web plate.

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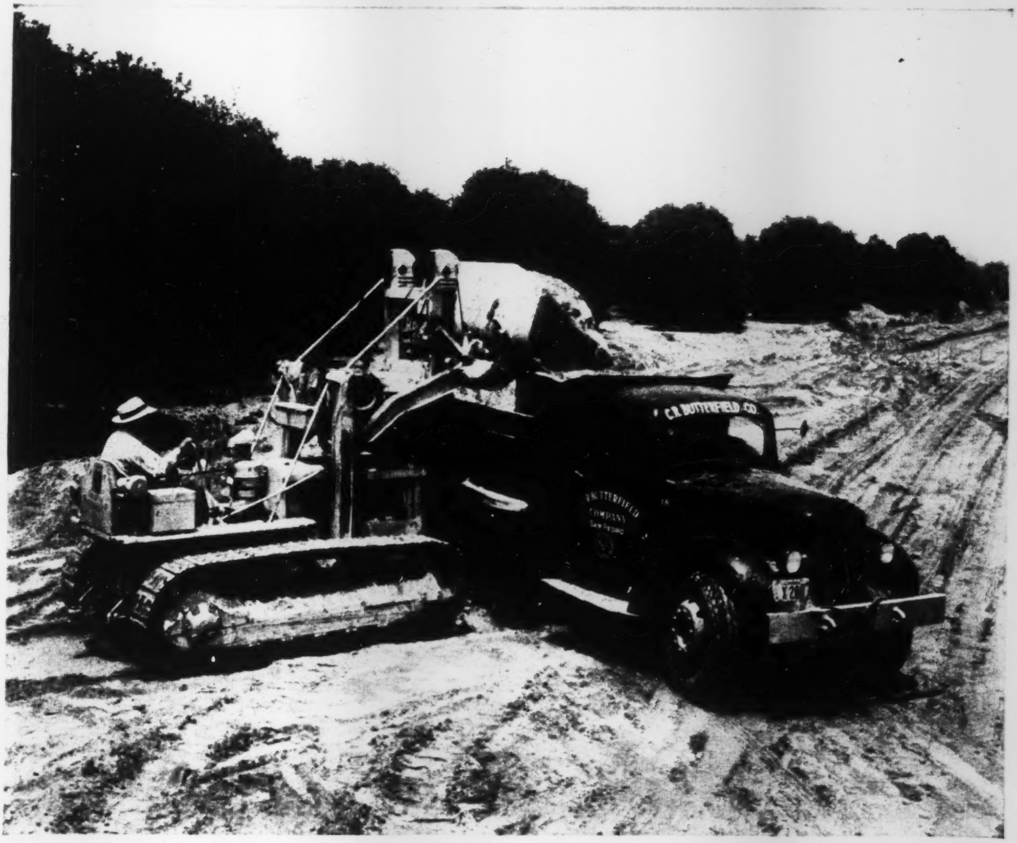

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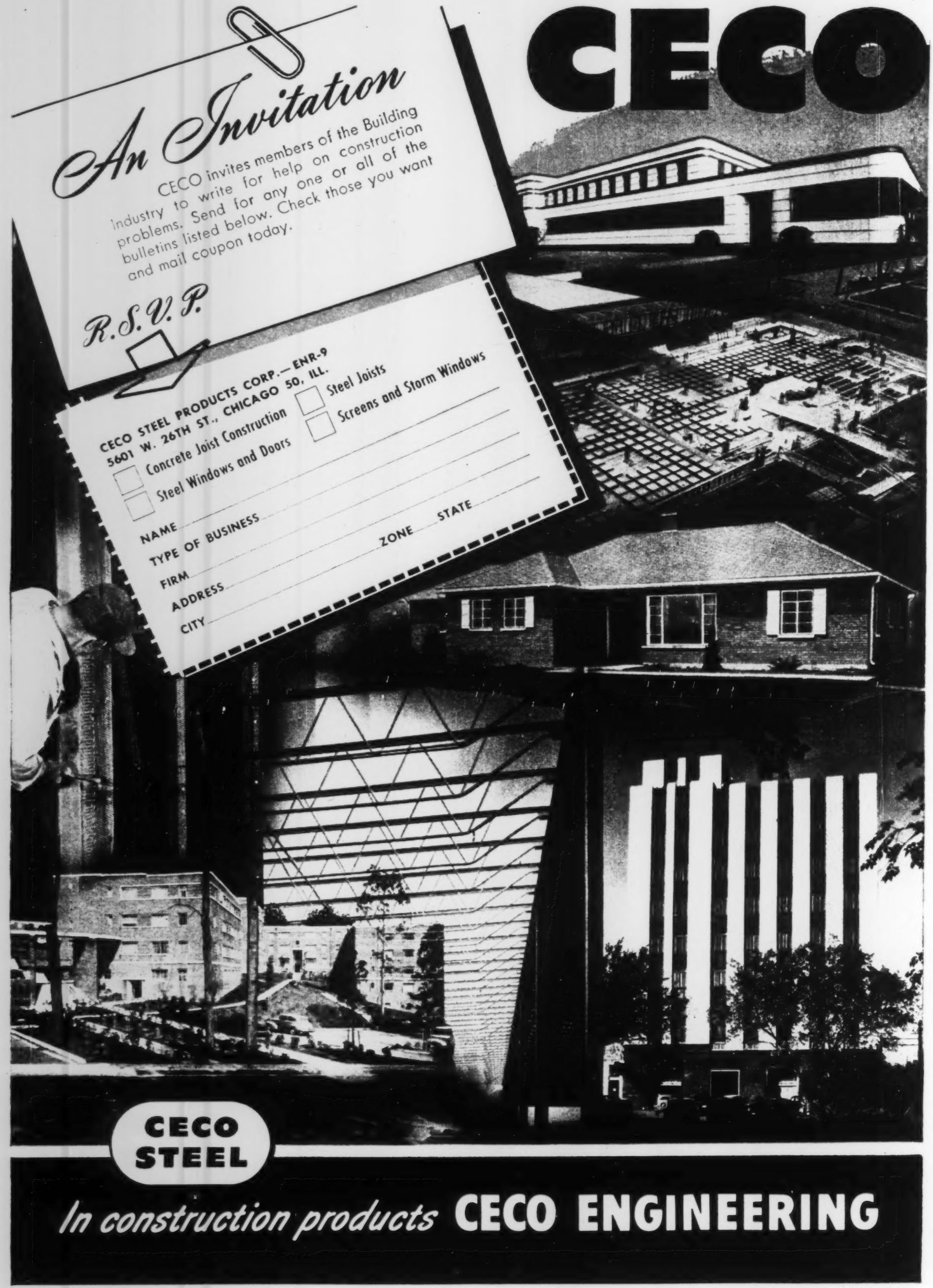

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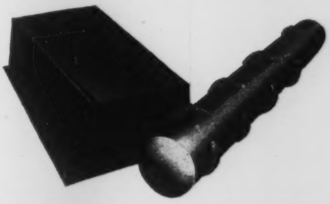

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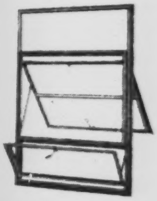

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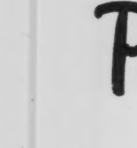

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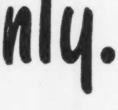

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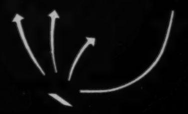
Here's a good example of the way "Caterpillar" bowl action funnels the material upward to make a heaped load faster, more easily.

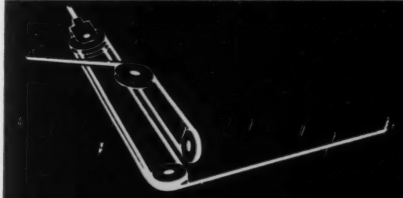
SCRAPERS

costs per yard



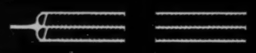
The "Caterpillar" Scraper blade is designed for *slicing* action in the cut. It digs faster, with less drawbar pull. And the apron is so designed that it won't clog the loading chute. It allows the material to *funnel* up from the blade without excessive packing.

Bigger tires on the "Caterpillar" Scraper give low rolling resistance on the haul. That means higher travel speeds and more trips per day. Big tires also allow very low tire pressures for greater flotation in soft earth. You can operate in working conditions that would bog down the average scraper.

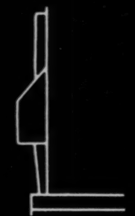


On the fill, the "Caterpillar" Cable Control system takes over to eject the material in smooth layers. Concealed sheaves and cable keep out abrasive material and result in longer cable life. Yet all cables can be replaced by a man standing on the ground. Sheaves are accurately aligned, heat-treated and machined, so that cable doesn't chafe or wear.

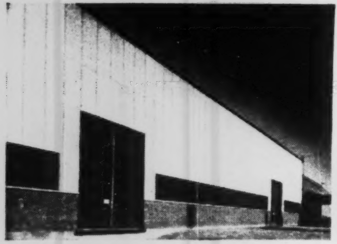
The apron lifts high, with no interference overhead. It is pivoted on the outside and well back on the bowl for ample load clearance when spreading material.



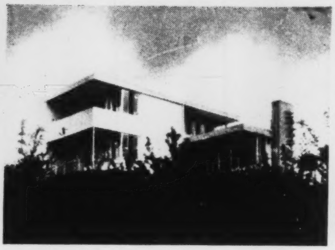
Four long flexible springs are hooked directly to the ejector plate to give a simple but dependable return action after a load is spread. Springs and ejector sheave systems are both well shielded from abrasive earth.



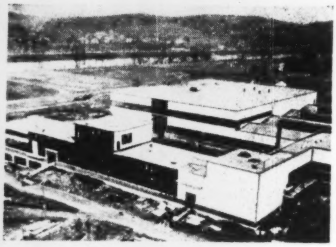
"Caterpillar" Scrapers are built to true "Caterpillar" quality standards. Box section double bottom and box section side walls, made from special high-tensile steels, are among the reasons why these units have exceptionally long work life.



Unique beauty of Cemesto in a curtain wall. Curtiss-Wright Corp., Louisville, Ky. Architect: Albert Kahn Associates, Inc., Detroit, Mich.



Modern residence of Berkeley, California. Architect: Richard J. Neutra.



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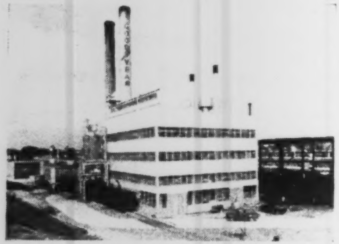

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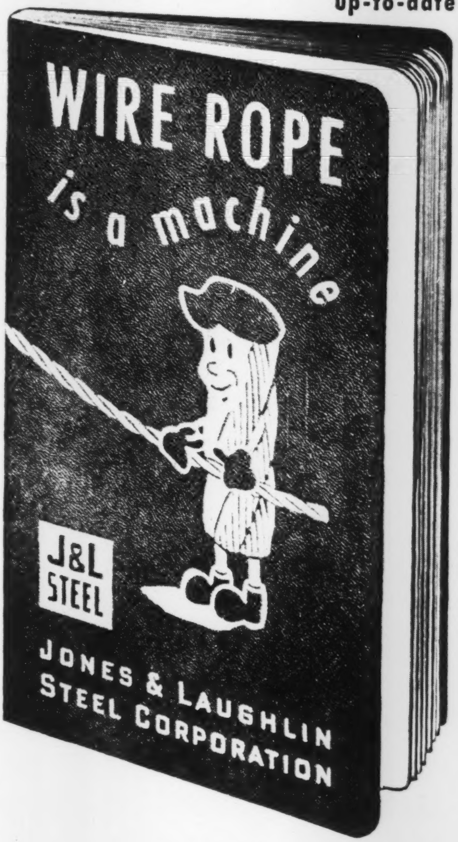

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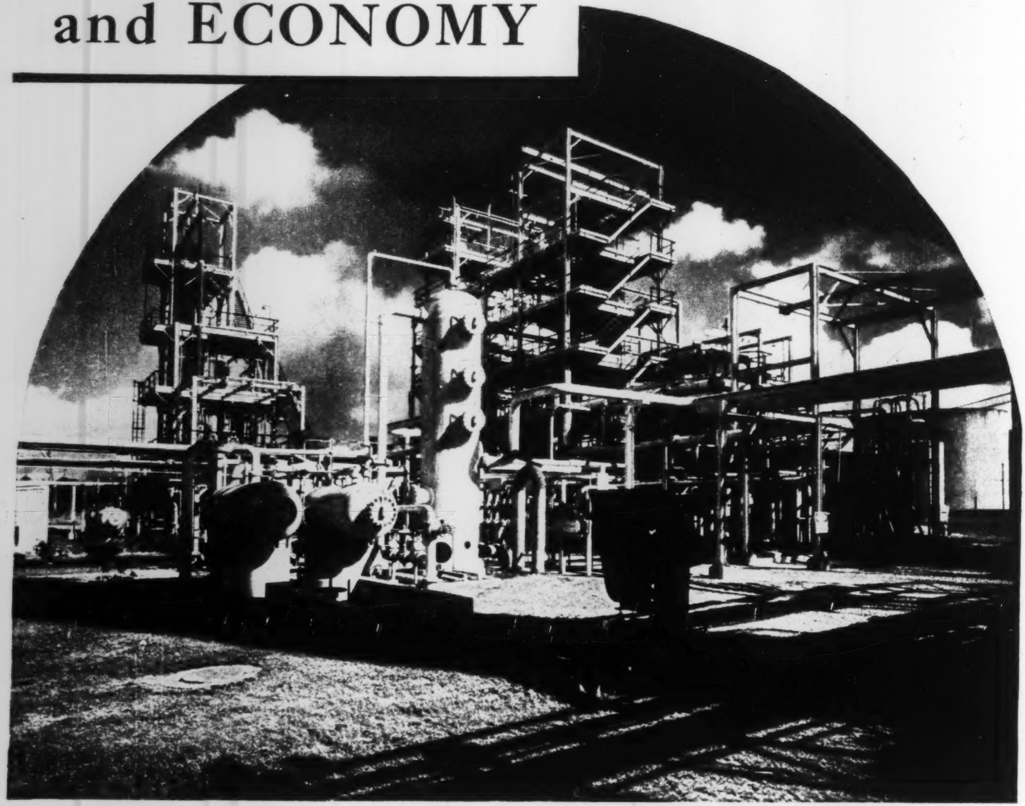

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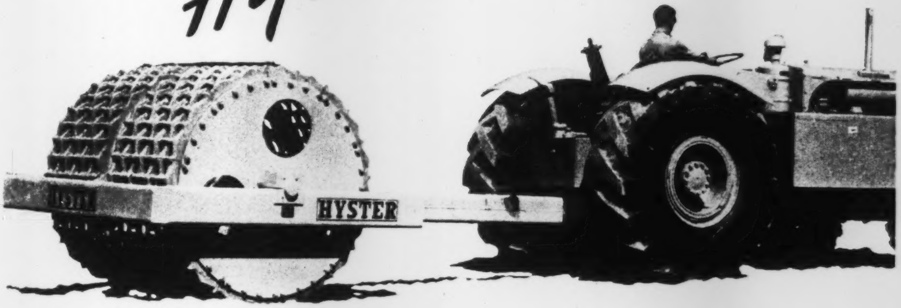

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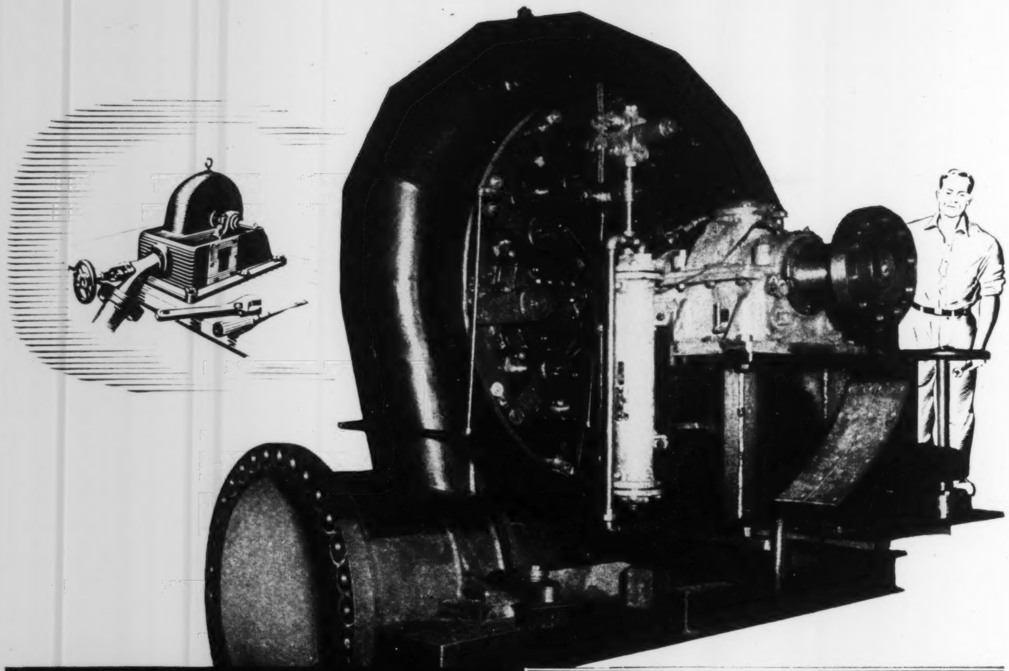

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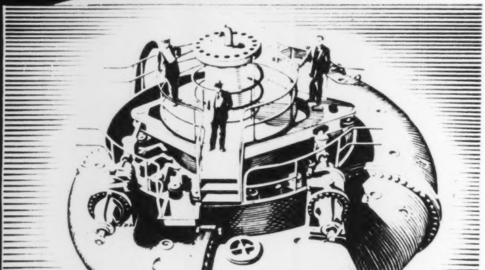

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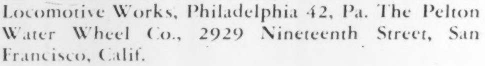
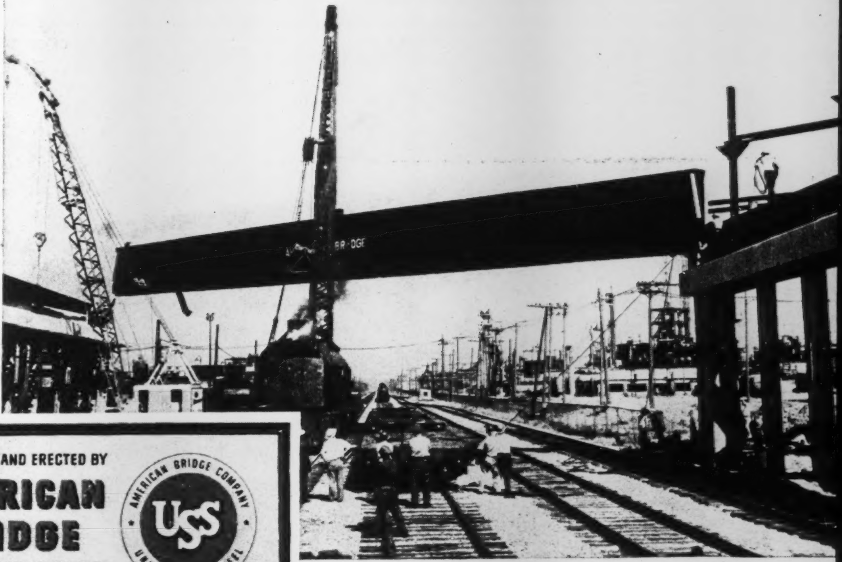
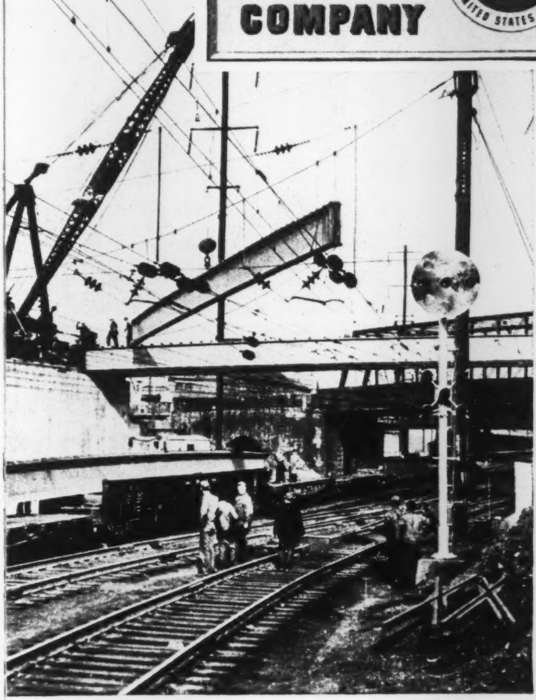


American Bridge erects an 88-ton, 140′ long plate girder span over the Chesapeake and Ohio Railway tracks in the yards of The Dow Chemical Company, Midland, Michigan. This structure was erected without hindering rail traffic. Darin & Armstrong, Inc., General Contractors; L. W. Millard, Consulting Engineer.



Erecting highway overpass above the Pennsylvania Railroad tracks, New York Division, Mercer County, Trenton, New Jersey. Despite the maze of electric transmission lines surrounding the work, and the rail traffic below, American Bridge completed the job successfully, without interruption to traffic. Kaufman Construction Company, Contractors; Designed by New Jersey State Highway Department.



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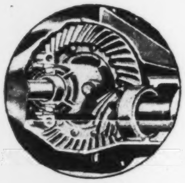
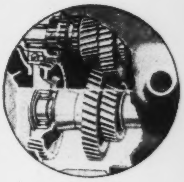
Mobilube GX

Great New Gear Oil for All Axle and Manually Shifted Transmission Gears!

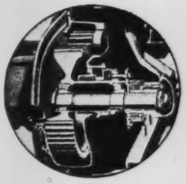


HYPOID

SPIRAL BEVEL



HELICAL



SPUR

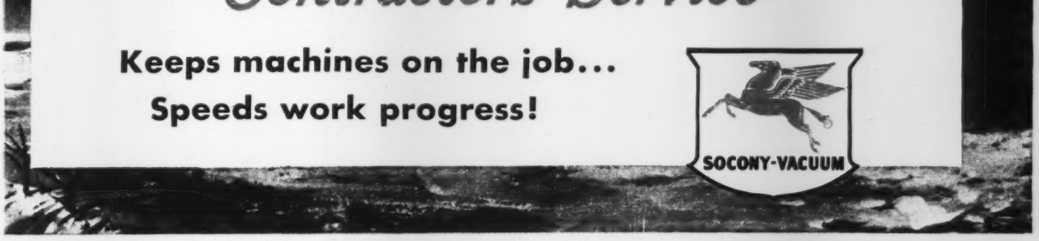
- **Reduces Inventory**
  Only one gear lubricant to stock!
- **Simplifies Application**
  Only one gear lubricant to handle!
- **Eliminates Error**
  Only one lubricant for all gears!

HERE'S *correct lubrication* for all gears—one big multi-purpose gear lubricant with 8 big features! New Mobilube GX protects fully . . . is non-deposit forming, non-corrosive even if water gets in housing . . . resists foaming . . . will not channel or separate in service or storage . . . gives extra rust protection, extra long service . . . makes gear shifting easy!

Made in 3 grades—S.A.E. 80, S.A.E. 90, S.A.E. 140—*new* Mobilube GX helps you cut costly equipment time out—keep machines on the job, paying off!

From now on, specify *new* Mobilube GX!

SOCONY-VACUUM OIL COMPANY, INC., and Affiliates: MAGNOLIA PETROLEUM CO., GENERAL PETROLEUM CORP.



SOCONY-VACUUM

Contractors' Service

Keeps machines on the job... Speeds work progress!

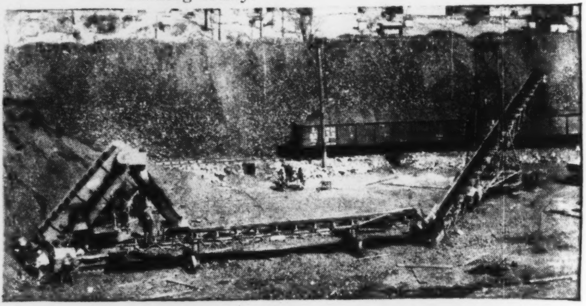
HAISS LOADER IN ACTION
(Note the full Buckets)

HAISS

•BUCKET LOADERS

Load 3 To 8 Yards Per Minute

Haiss Bucket Loaders are used for excavating — rehandling — stripping and loading: sand — gravel — stone top-soil — coal and similar materials. Self Propelled, Self Feeding — wheel or crawler mounted — One man operation. Write for Bucket Loader Catalog today.



HAISS LOADER and
Conveyors Combination

•CONVEYORS

portable or
stationary

CAR UNLOADERS

HAISS FLAT or TROUGH BELT CONVEYORS
(Model 481 and 482)

For all bulk materials. Mounted on "V" or mast truck with swivel wheels. Ask for Bulletin No. 481 for coal or coke handling—Bulletin No. 482 for sand and gravel, etc.

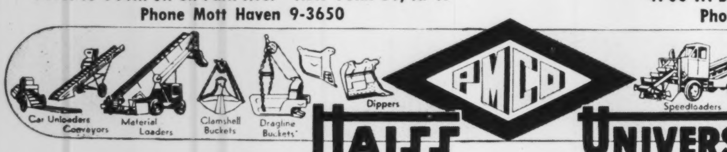
HAISS CAR UNLOADERS
(Models 483 and 484)

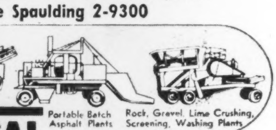
Belt and drag types for low-cost undercar unloading from hopper bottom cars. Ask for bulletin No. 483-4.

•BUCKETS

HAISS SECTIONAL CONVEYORS

Made in easily assembled sections. Portable as above or stationary as below — for handling all bulk materials — Ask for Bulletin 487.





EXCAVATING — REHANDLING

Experienced Haiss representatives are located in all principal cities. For further information, write, phone or wire.

GEORGE HAISS MFG. CO., INC. division of **PETTIBONE MULLIKEN CORP.**

141st to 144th St. on Park Ave. NEW YORK 51, N. Y.
Phone Mott Haven 9-3650

4700 W. Division St. CHICAGO 51, ILL.
Phone Spaulding 2-9300

Car Unloaders
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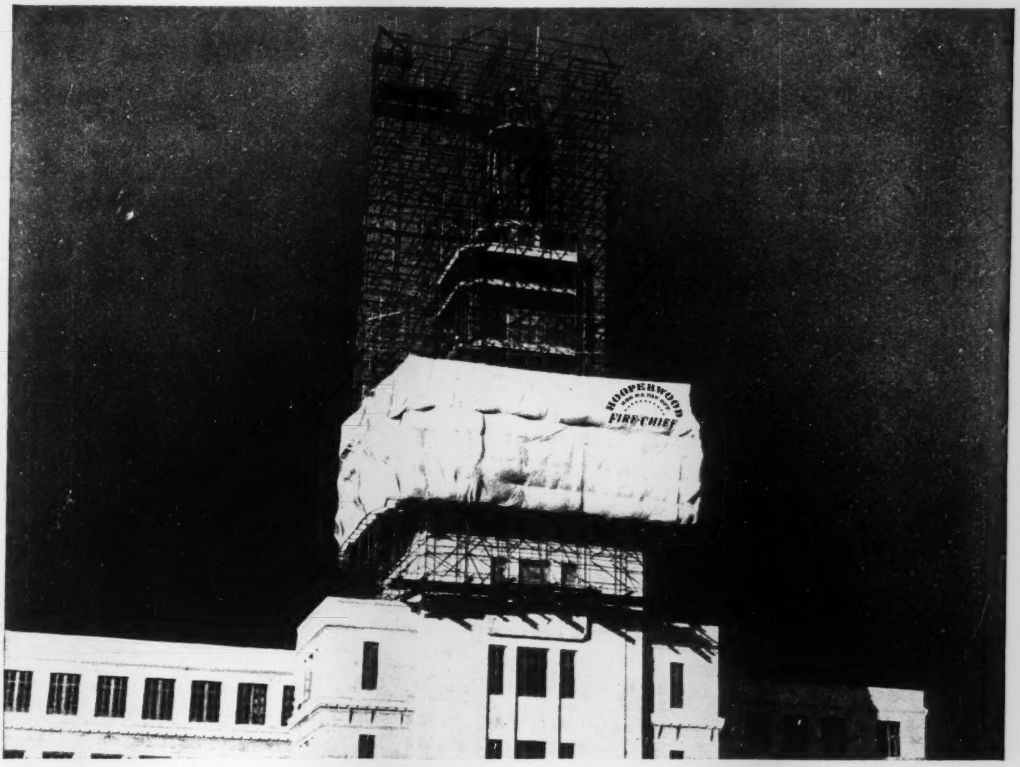
Clamshell Buckets
Dragline Buckets
Dippers
PMCD
HAISS
UNIVERSAL
Speedloaders
Portable Batch Asphalt Plants
Rock, Gravel, Lime Crushing, Screening, Washing Plants

NEW YORK, N. Y.

CEDAR RAPIDS, IOWA.



FIRE-CHIEF "Ear Muffs" Protect Construction Job 50 Floors Up!

Howling wind and biting cold make construction workers' jobs plenty hazardous. The danger of a spark igniting protective canvas adds another hazard. But Hooperwood FIRE CHIEF Canvas eliminates all these dangers.

FIRE CHIEF Canvas is the treated canvas that resists fire, water, weather, mildew and wear. The construction industry uses thousands of yards of it a year for tarpaulins, protective curtains, machinery covers, etc.

Whatever the industry, whatever the requirements for canvas, if you insist on the Hooperwood name you'll be getting canvas at its best.

HOOPERWOOD *Serves Industry*

with FIRE CHIEF Canvas, Kushon Kloth, Imperial Rope, Sterling Sash Cord, Hooperwood Dryer Felts and Hooperwood Filter Fabrics.

WM. E. HOOPER & SONS CO.

General Sales Offices:
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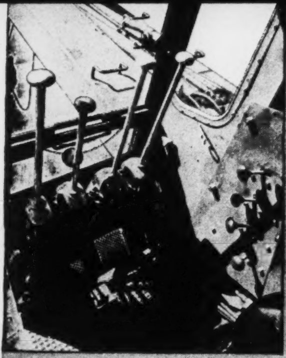
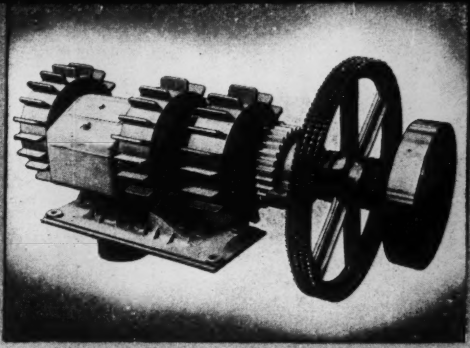
Hooperwood Mills: Woodberry, Baltimore, Md.

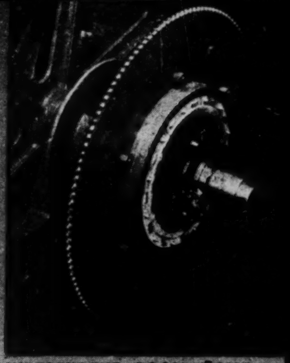
IN THE MONTHS AHEAD
YOU'LL NEED A FAST,
POWERFUL, DEPENDABLE,
ECONOMICAL MACHINE
like this...
MARION
33-M
MARION
MARION
33-M



AIR CONTROL—all motions controlled by air. Simple—easy to operate—powerful.

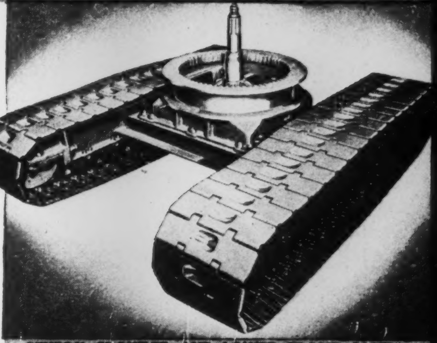


SWING SHAFT—This swing, propel and crowd retract shaft assembly is equipped with three Fawick Airflex clutches which require no adjustment at any time. Special heat dissipating fins assure cool running clutches.



INDEPENDENT BOOM HOIST, standard on all machines, for high speed operation and safe lowering of boom.

THE BIGGEST LITTLE MACHINE ON CRAWLERS . . .



STURDY CRAWLER AND LOWER FRAME ASSEMBLY—self-cleaning, non-clogging crawlers assure free operation under difficult ground conditions.

Fast . . . powerful . . . a big yardage producer . . . describes the MARION 33-M shovel.

SIMPLICITY OF DESIGN—clean and compact throughout.

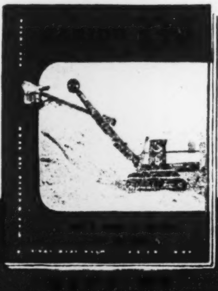
STURDY CONSTRUCTION—built for maximum strength, long life service and low maintenance. EASE OF CONTROL—all motions, steering, propelling, braking, swing brake, dipper trip, and gear changes are AIR CONTROLLED.

EASE OF MAINTENANCE—brake adjustments, all machinery, and lubricating fittings are readily accessible. Only one adjustment for hoist and crowd out clutches. No adjustments needed for swing, propel, crowd retract or boom hoist clutches. READILY CONVERTIBLE—from one front end to another.

These and many more desirable features make the MARION 33-M a fast, powerful, dependable and economical machine.

COMPACT, ACCESSIBLE MACHINERY easy to get at for daily routine attention. Mounted on sturdy cast-welded main frame.

From 3/4 Cu. Yd.
POWER SHOVEL COMPANY
MARION
SINCE 1884
To [illegible]

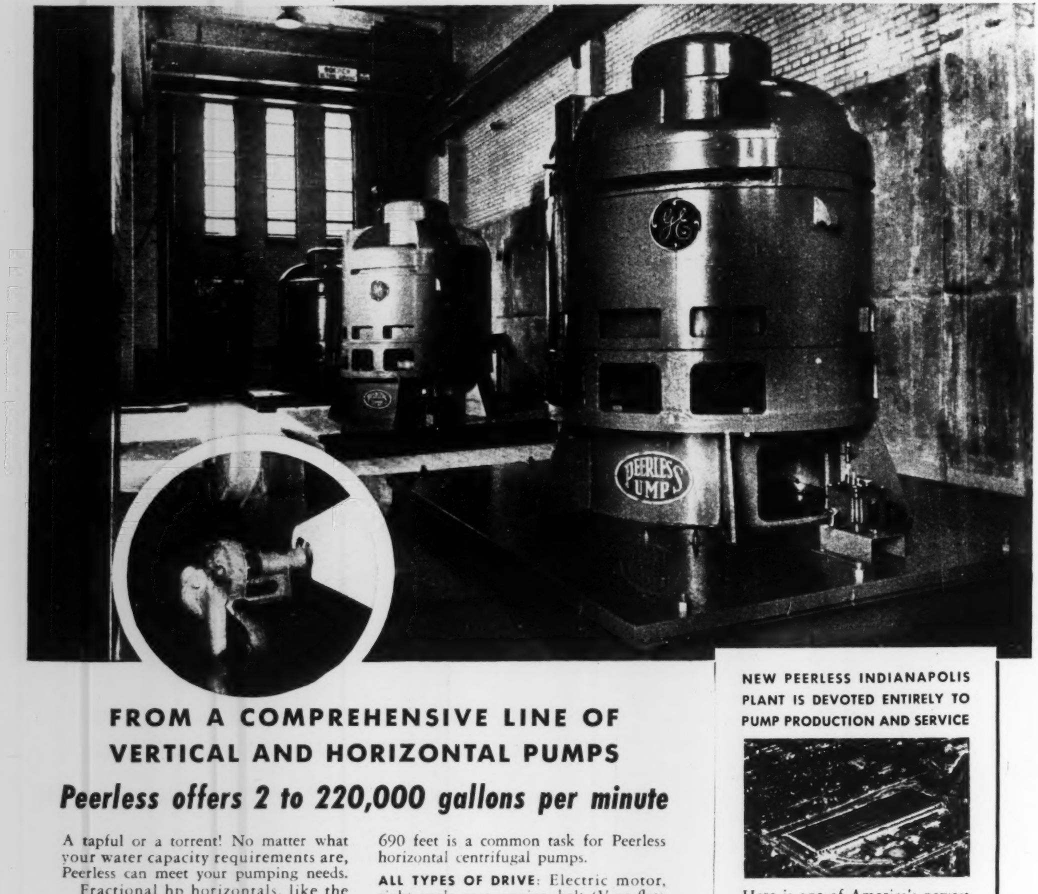


33-M BULLETIN
It will give you all of the facts about the 33-M built to move yards fast at low cost. Send for it today!

MARION

POWER SHOVEL COMPANY, MARION, OHIO, U. S. A.
Offices and Warehouses in all Principal Cities ● Established 1884

WIDEST CAPACITY RANGE



FROM A COMPREHENSIVE LINE OF VERTICAL AND HORIZONTAL PUMPS

Peerless offers 2 to 220,000 gallons per minute

A tapful or a torrent! No matter what your water capacity requirements are, Peerless can meet your pumping needs.

Fractional hp horizontals, like the Peerless "Fluidyne" pumps handling cooling-jacket water in the inset above, furnish a few gallons a minute. The huge Peerless mixed-flow pumps in the larger photo, pump away drainage water at the rate of tens of thousands of gallons a minute.

Widest capacity range is but one of a host of reasons why industries, municipalities and commercial businesses plan with Peerless for all their needs for pumps. Here are others:

ALL PRACTICAL HEADS: Lifting water from 1000 feet or more is a practical accomplishment of Peerless vertical deep well pumps. Pumping against heads of 690 feet is a common task for Peerless horizontal centrifugal pumps.

ALL TYPES OF DRIVE: Electric motor, right angle gear, engine, belt (V or flat) or combinations of the above, are all available from Peerless, with pump and driver engineered as a unit.

MODERN DESIGN: Peerless pumps are designed for top flight performance over extended periods of time. And the practical consideration of ease of maintenance and repair is figured in to their functional, good looking design.

NATIONWIDE SERVICE: Peerless sales and field service is available in all principal U. S. cities and abroad. Plan with Peerless for all your pumping needs. Individual bulletins on all types of Peerless Pumps are available upon request.

NEW PEERLESS INDIANAPOLIS PLANT IS DEVOTED ENTIRELY TO PUMP PRODUCTION AND SERVICE

Here is one of America's newest pump plants—19 acres of modern manufacturing facilities devoted to precision production of horizontal and vertical pumps, centrally located at Indianapolis. Plan with Peerless for pumps plus fast, complete pump service.

Peerless
VERTICAL AND HORIZONTAL
Pumps

PEERLESS PUMP DIVISION
FOOD MACHINERY AND CHEMICAL CORPORATION
Los Angeles 31, California Indianapolis, Indiana
District Offices: New York 5, 37 Wall Street; Chicago 40, 4554 N. Broadway; Atlanta Office: Rutland Bldg., Decatur, Ga.; Omaha, Nebr., 4330 Leavenworth Street; Dallas 1, Texas, 3905 Elm Street; Fresno, Calif.; Los Angeles 31, Calif.

WICKWIRE ROPE A PRODUCT OF CF&I

Ask any user . . . you'll find them everywhere

In scores of industries, users of Wickwire Rope have developed an affectionate respect for its performance, safety and long life. And, for true economy, they use Wickwire's WISSCOLAY® Preformed. It lasts longer—is easier to cut, splice and install. It's kink-resistant and safer to handle. Wickwire Distributors and Rope Engineers, in key cities everywhere, are prepared to render prompt service in meeting your wire rope needs. Wickwire Rope Sales Office and Plant—Palmer, Mass.

IN THE EAST—Wickwire Spencer Steel Div. of C. F. & I.
500 Fifth Ave., New York 18, N. Y.
IN THE ROCKIES—The Colorado Fuel and Iron Corp.
Continental Oil Bldg., Denver, Colo.
ON THE WEST COAST—The California Wire Cloth Corp.
1080—19th Ave., Oakland 6, Cal.

LOGGING
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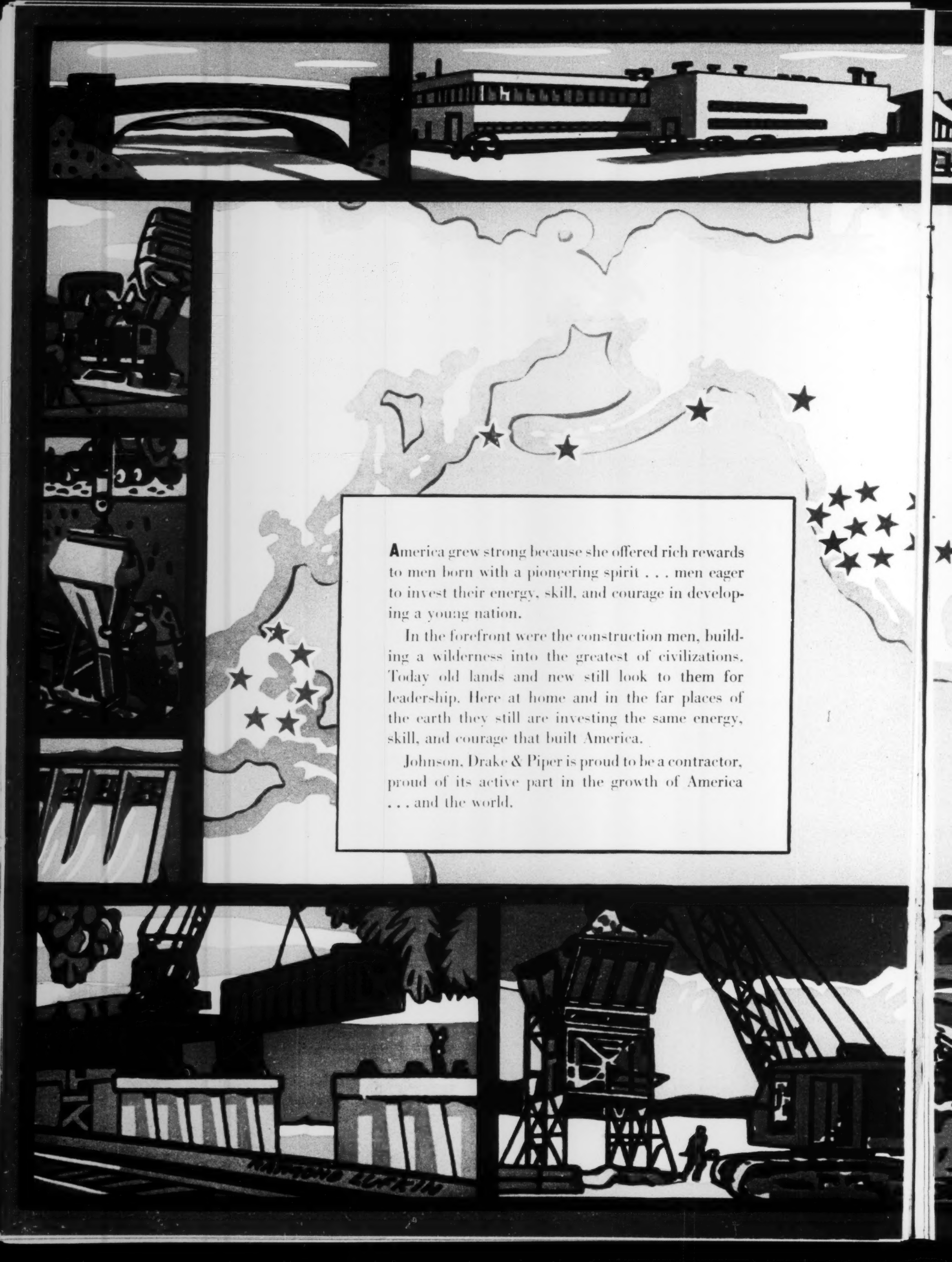
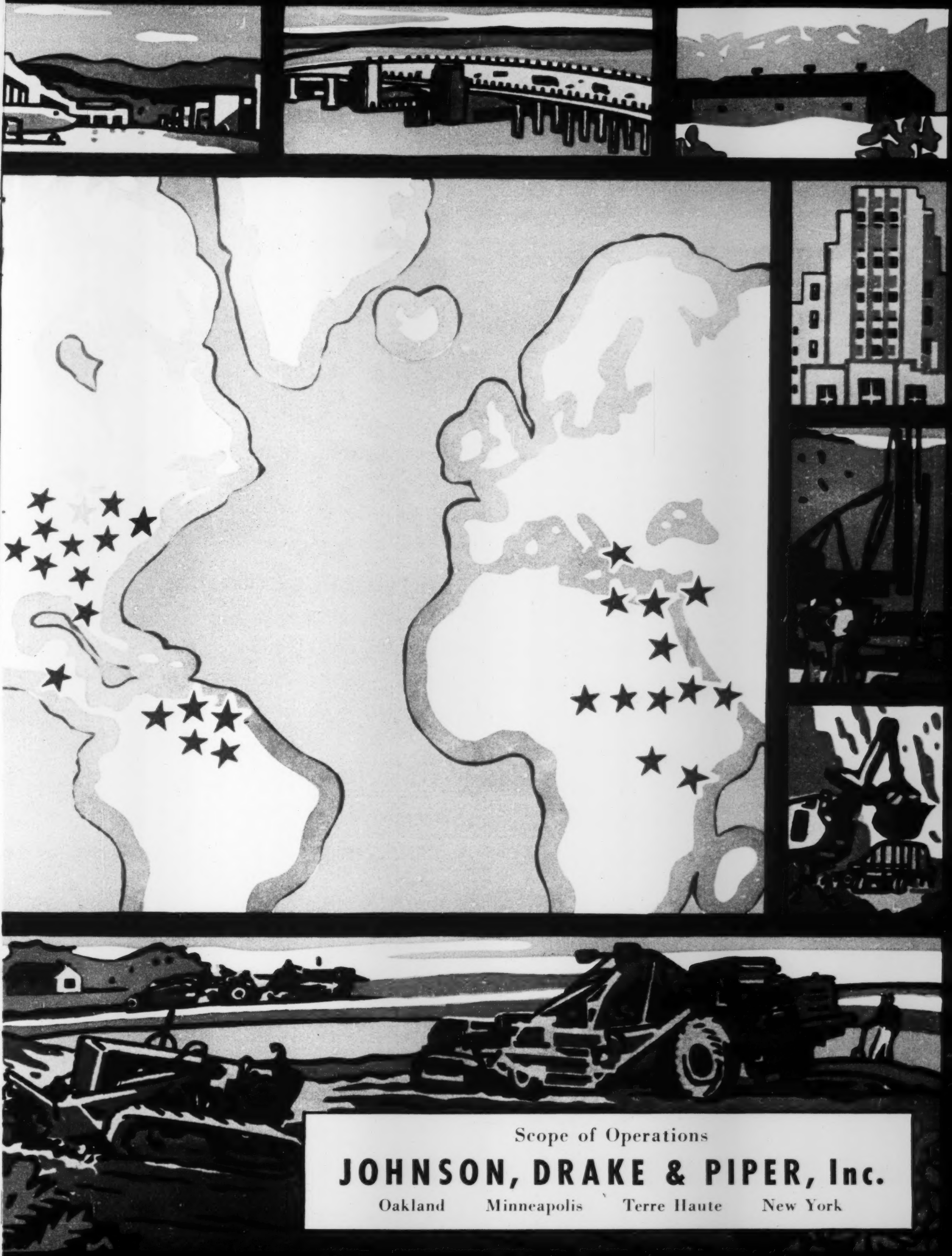
PETROLEUM
MANUFACTURING
MARINE
CONSTRUCTION
A. E. Brotman



America grew strong because she offered rich rewards to men born with a pioneering spirit . . . men eager to invest their energy, skill, and courage in developing a young nation.

In the forefront were the construction men, building a wilderness into the greatest of civilizations. Today old lands and new still look to them for leadership. Here at home and in the far places of the earth they still are investing the same energy, skill, and courage that built America.

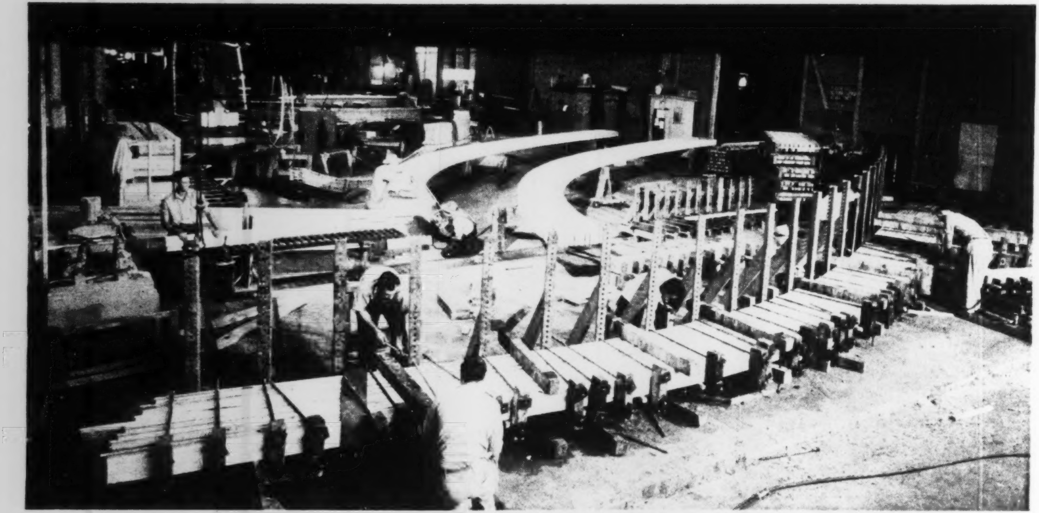
Johnson, Drake & Piper is proud to be a contractor, proud of its active part in the growth of America . . . and the world.



Scope of Operations

JOHNSON, DRAKE & PIPER, Inc.

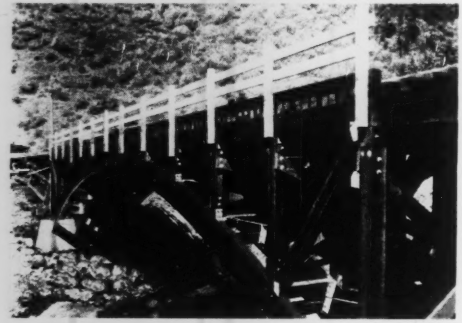
Oakland Minneapolis Terre Haute New York



Forming arch in Portland, Oregon, plant of Timber Structures, Inc.

"SHOP GROWN" Timbers

...the Newest and Finest of Engineered Structural Materials



Pacific Northwest railroad and truck bridge supported by four glued laminated arches. Cooper's E-50 loading.

Glued laminated beams in automobile service shop. Camber may be built in as desired.

Completely detailed and shop fabricated, with all the advantages of timber and without its few disadvantages, Timber Structures glued laminated members are the ideal structural material for many forms of modern construction.

Stronger than sawn timbers of equal size, these members are moulded to the exact shape specified by the designer. Size and shape are limited only by facilities for handling and shipping.

Timber Structures glued laminated members are composed of structural quality Douglas fir, kiln dried to approximately the same moisture conditions as the area in which they will be used. They retain their shape and strength permanently, without shrinking, checking, twisting or warping.

For long-time exterior use, or when termite protection is necessary, the same treatments are suitable for glulam work as for sawn stock. Retaining all the natural fire resistivity of wood, Timber Structures glued laminated members are classed as heavy timber construction, with lessened fire hazard and usually reduced fire insurance premiums. Further fire retardance may be had by standard impregnation treatments.

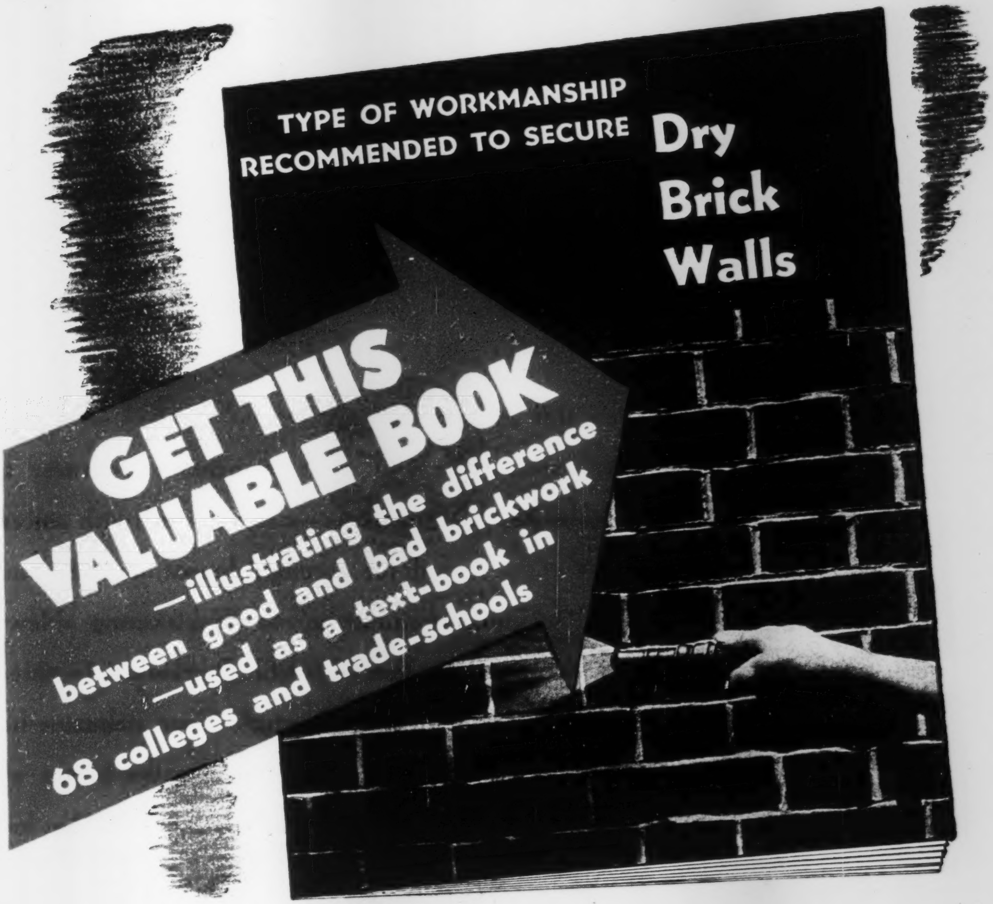
The Timber Structures office nearest you will give you full information about adapting these glued laminated members to your structural or architectural requirements. Or write directly to us.

TIMBER STRUCTURES, INC.

P.O. BOX 3782, PORTLAND 8, OREGON

Offices in Boise, Idaho; Eugene, Oregon; Lawrenceville, N.J.;
Chicago; Dallas; New York; Seattle; Spokane

TIMBER STRUCTURES, INC. OF CALIFORNIA • Oakland and Sacramento
Local representatives coast to coast.


TYPE OF WORKMANSHIP RECOMMENDED TO SECURE Dry Brick Walls
GET THIS VALUABLE BOOK
—illustrating the difference between good and bad brickwork
—used as a text-book in 68 colleges and trade-schools

FOR many years intensive research on the cause and prevention of leaky brick walls has been conducted by various organizations and individuals, and much vital information has been gathered.

Most authorities agree that *workmanship* is the most important thing involved, but until now, no one has attempted to explain and *illustrate* the difference between good and bad workmanship.

"Type of Workmanship Recommended to Secure Dry Brick Walls" does just that. In it, a recognized authority on brickwork has compiled 16 pages of proven information — explanations and recommendations — 96 color illustrations. It is a major contribution to *good building.* It is *not* an advertisement for our product, Brixment. It is published as a *service* to the building trades. It will be sent free to any architect, contractor, bricklayer or dealer who is interested in water-tight masonry.

Use the coupon to secure your copy. No obligation of any sort.

Louisville Cement Co., *Incorporated*
311 Guthrie Street, Louisville 2, Kentucky
Gentlemen: Without obligation, please send me a copy of "Type of Workmanship Recommended to Secure Dry Brick Walls."
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Firm______________________________
Street_____________________________
City_________________State__________

THE ASSOCIATED GENERAL CONTRACTORS OF AMERICA
AGC
REG. U.S. PAT. OFF.

As one Old-Timer to another, and with sincere regard for accomplishment, we offer our congratulations to Engineering News-Record on its outstanding service for three-quarters of a century. Your magazine has been on our desks since we began our business nearly fifty years ago. We look forward with pleasure to continuing our relationship for the years to come.

1901 ★

WE HAVE served the railroads of this country and Canada — power companies, federal agencies — states, counties, and municipalities—and prominent manufacturing firms throughout the country.

Our services have included the building of bridges of all types—tunnels of all kinds—dams of earth, rock, and concrete —complete railroads systems (steam and electric)—highways —sewage disposal systems—water supply projects—irrigation and flood control works—wooden ships—steel landing barges and drydocks—blast furnaces and power plants.

Skill—Integrity—Responsibility . . . have keynoted this organization for nearly half a century.

•1949

BATES & ROGERS CONSTRUCTION CORPORATION

General Contractors

CHICAGO 6 • • 600 WEST JACKSON BLVD.
SAN FRANCISCO 2 • • • 209 POST STREET

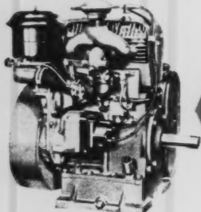
Here's *Proof* of *Preference* for WISCONSIN HEAVY-DUTY *Air-Cooled* ENGINES

40% OF ALL CARBURETOR TYPE ENGINES MADE DURING 1947 within the 2 to 30 H.P. Range WERE WISCONSINS . . . . .

These are the ENGINES

According to an official bulletin issued on April 22, 1949 by The Bureau of Census, U. S. Dept. of Commerce (Preliminary Industry Report, Series MC-31D, covering the production of Internal Combustion Engines in 1947), 4 out of every 10 carburetor type engines within our power range, were produced by Wisconsin Motor Corporation. Here are the actual figures:

CUBIC INCH DISPLACEMENT	HORSE POWER RANGE	TOTAL NUMBER OF ENGINES BUILT FOR RESALE	TOTAL WISCONSIN MODELS BUILT FOR RESALE	PERCENTAGE OF TOTAL BUILT BY WISCONSIN
11.0 to 20.9	**2 to 5**	173,964	90,106	51.7%
21.0 to 50.9	**5 to 9**	174,746	63,632	36.4%
76 to 100.9	**15 to 22**	56,324	40,305	71.6%
101 to 175.9	**25 to 40**	123,029	18,131	14.7%
TOTALS		**528,063**	**212,174**	**40.2%**

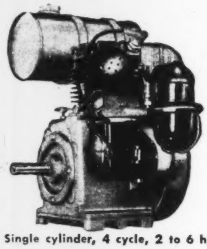


Since these amazing figures were recorded, we have added two new air-cooled models, the TE- 2 cylinder having a displacement of 45.9 cu. inches and the TF- 2 cylinder with a displacement of 53.9 cu. inches. The horsepower range is from 8.5 to 13.3 for these models. The immediate popular acceptance of these engines and the growing demand for them has already placed them on a par with other top-ranking engines in the Wisconsin line.

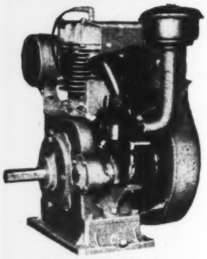
Most Wanted! Most Made! Most Sold!

The summary given above includes data received by the Census Bureau from 134 engine manufacturers. The groups given here does not include automotive, aircraft and outboard marine engines, built in 1947 for resale as separate power units or for use as original equipment by various equipment manufacturers for their own use.

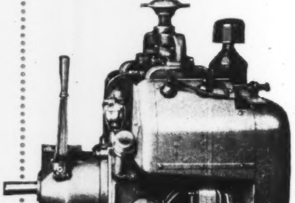
These statistics do show, however, the actual output of engines for resale . . . and the predominant percentages in favor of Wisconsin Heavy-Duty Air-Cooled Engines. **What better indication could be asked than this, showing the outstanding preference for these engines among users. The figures speak for themselves.**



Single cylinder, 4 cycle, 2 to 6 hp.



Single cylinder, 6 to 9 hp.



V-type, 4-cylinder, 15 to 30 hp.

MOST H.P. HOURS

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 14, WISCONSIN

Another outstanding Fenestra Panel job!

One of the twin recreation buildings for Endicott-Johnson Corporation, Endicott and Johnson City, New York. Each identical building contains 12,450 sq. ft. of insulated walls and 51,750 sq. ft. of acoustically-treated, cellular building panel floors and roofs—all Fenestra. Architect: A. T. Lacey & Sons, Binghamton, N. Y. Contractor: Vincent J. Smith, Inc., Binghamton, N. Y.

. . . in our 25th year of light-gage steel fabrication

You learn a lot about sheet steel fabrication in 25 years.

Steel roof deck, originated by Fenestra* Holorib in 1924, began the large scale commercial use of sheet steel as a building material. Holorib's strong pyramidal rib, full support for insulation, full last rib to eliminate asphalt leakage, telescoping end laps and interlocking side laps are features which construction men readily appreciated.

You prove a lot in 25 years, too. Holorib roofs laid down in 1924 are still good roofs—living up to their promises.

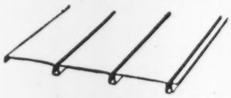
Holorib's success led us to develop new ideas, to the perfection of cellular building panels for floors, walls, ceiling and roofs—the entire enclosure.

Fenestra developed panel types D and AD with high strength-weight ratios. A maximum of material is away from the neutral axis, giving full support for fill or insulating materials, enabling you to keep quantities of those materials to a minimum. Acoustically treated, through Fenestra's perforating and adding of a sound element, they provide economical combined ceilings and roofs for schoolrooms, auditoriums and gymnasiums.

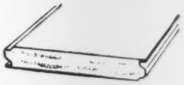
Fenestra's type C panel provides a 3-inch insulated wall equivalent to a 12-inch brick wall. These panels may be erected in vertical or horizontal position.

Fenestra Metal Building Panels are designed to reduce dead loads. They save construction time and money. Laid in long spans, they fit together easily, speedily. Fenestra floors enable other trades to move in faster—Fenestra walls speed enclosure, permit earlier building occupation.

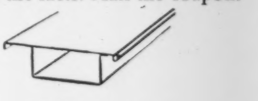
Fenestra's fund of practical knowledge on modern building technology is ready for you to tap. Get the facts. Mail the coupon.



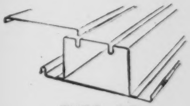
HOLORIB



TYPE C



TYPE D



TYPE AD

*Trademark

Fenestra

METAL BUILDING PANELS

ROOFS · WALLS · FLOORS

DETROIT STEEL PRODUCTS COMPANY
Building Panels Division
Dept. EN-9, 2272 E. Grand Boulevard
Detroit 11, Michigan

☐Please have an engineering representative call.

☐Please send me, without obligation, information on Fenestra Building Panels.

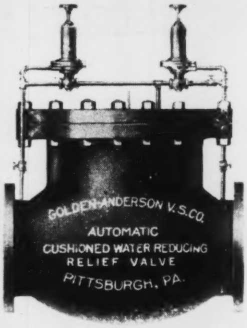
Name

Company

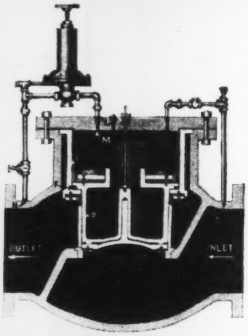
Address

ANDERSON V.S.CO.
REDUCING VALVE
PITTSBURGH

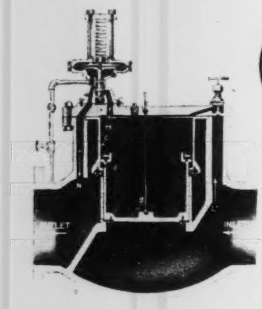
G-A Water Pressure Reducing Valve maintains constant downstream pressure against higher upstream head.


GOLDEN-ANDERSON V.S.CO.
AUTOMATIC
CUSHIONED WATER REDUCING
RELIEF VALVE
PITTSBURGH, PA.

G-A Water Pressure Reducing and Relief Valve maintains downstream pressure as adjustment is made against any higher upstream head.


M
OUTLET
INLET

G-A Water Pressure Reducing and Check Valve has "stop piston" to prevent downstream pressure from returning back through the valve.


N
OUTLET
INLET

G-A Single Acting Semi-Throttling Altitude Valve maintains desired water level to prevent overflow.

GA

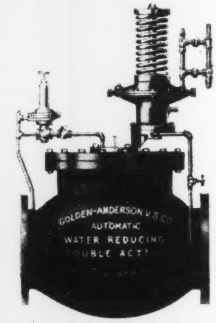
Golden-Anderson

designers and
builders

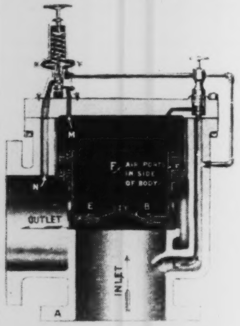
WATER PRESSURE

Valves

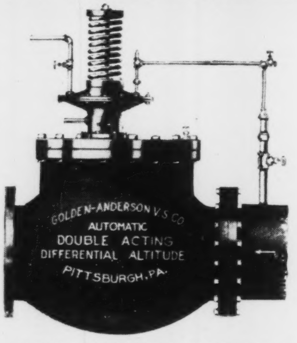
for every service
installation


GOLDEN-ANDERSON V.S.CO.
AUTOMATIC
WATER REDUCING
DOUBLE ACTING

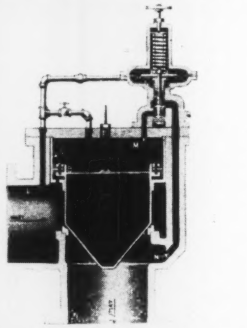
G-A Water Pressure Reducing and Double Acting Water Level Control Valve is ideal where low and high pressure zones are maintained.


M
F
AIR PORT IN SIDE OF BODY
N
OUTLET
E
B
INLET
A

G-A Water Pressure Relief Valve, angle pattern, automatically opens to maintain desired line pressure.


GOLDEN-ANDERSON V.S.CO.
AUTOMATIC
DOUBLE ACTING
DIFFERENTIAL ALTITUDE
PITTSBURGH, PA.

G-A Double Acting Differential Altitude Valve assures unfailing water level control with 3" to 12" variation.



G-A Water Pressure Relief Valve is furnished in either standard piston type or in needle piston type as shown here.

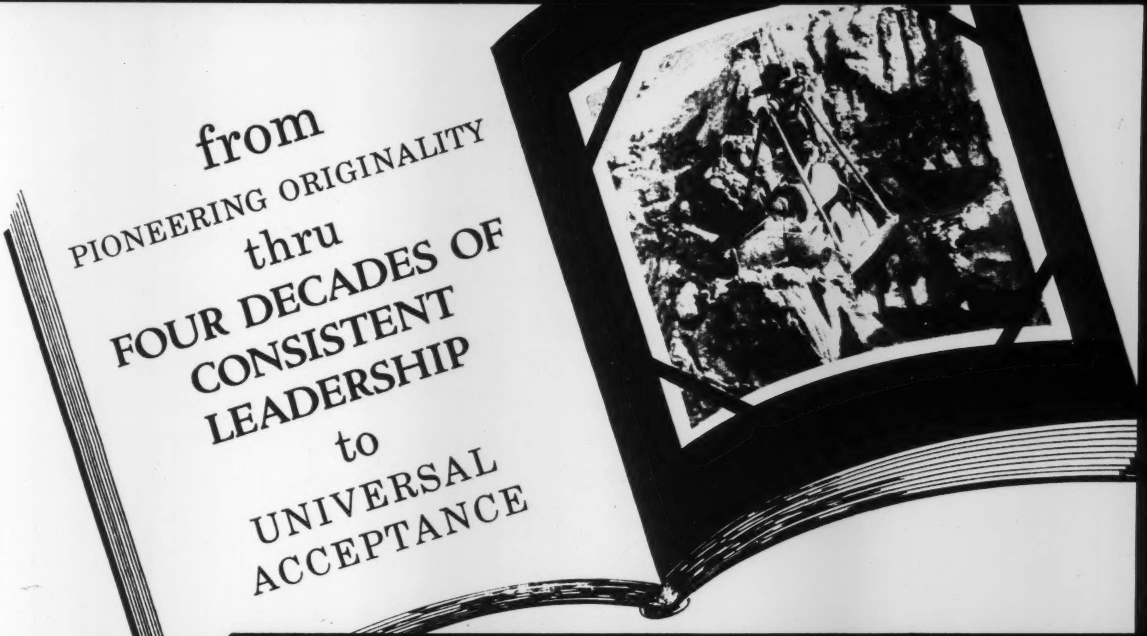
Let our Engineers Help Solve Your Valve Problems with a specially designed valve or one of 1500 types and sizes of standard Golden-Anderson Valves.

GA

GOLDEN-ANDERSON *Valve* SPECIALTY CO.

Keenan Building, Pittsburgh 22, Pa.

LIFE AND PROPERTY PROTECTION
VALVES SINCE 1905



from
PIONEERING ORIGINALITY
thru
FOUR DECADES OF
CONSISTENT
LEADERSHIP
to
UNIVERSAL
ACCEPTANCE

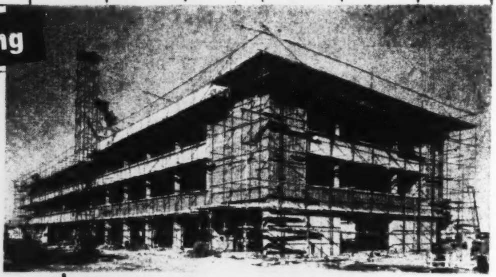
Owen Buckets

and OWEN
GRAPPLES

THE OWEN BUCKET COMPANY
6010 Breakwater Ave. • Cleveland 2, Ohio
Branches
New York, Philadelphia, Chicago, Berkeley, California

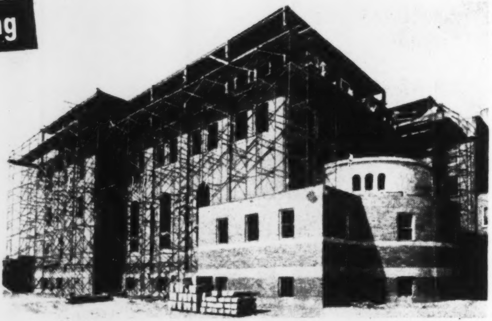
How Safe, Efficient Scaffolding Saves Time and Money on Every Job!

"TUBELOX" Tubular Steel Scaffolding



Vastly stronger than wood and firesafe, Tubelox Steel Scaffolding can be erected and dismantled with speed and safety . . . Only four basic parts are required. On outside jobs, the slender, sturdy steel tube offers minimum wind resistance; on inside jobs in churches, banks and public buildings — it cuts obstruction of view to a minimum. Write for Bulletins 10-PTS and PTS-13.

"TROUBLE SAVER" Sectional Steel Scaffolding



Prefabricated to save erection time. All parts are interchangeable. Welded construction assures maximum strength. No tools are required for assembly. "Trouble Saver" Sectional Steel Scaffolds can be quickly assembled, without any complicated parts, to fit the specific needs of individual jobs. Approved by Underwriters' Laboratories, Inc., "Trouble Saver" Scaffolding is strong, safe and long-lasting. *Write for Bulletin PSS-12.*

● You can cut your labor costs on all construction, remodelling or maintenance work with GOLD MEDAL Tubelox Scaffolding or "Trouble Saver" Sectional Steel Scaffolding. Indoors or out—you can save many costly "man hours." With full confidence in these scaffolds, your men will do more and better work in less time.

To get these advantages — and extra profits — specify GOLD MEDAL Tubelox Scaffolding or "Trouble Saver" Sectional Steel Scaffolding . . . skillfully fabricated in our own completely-equipped factories from *the best* materials. On large jobs or small, leading builders, contractors, construction and maintenance men depend on this safe equipment.

● NATION-WIDE SCAFFOLDING SERVICE

The Patent Scaffolding Co., Inc. is a pioneer in originating, developing and improving many types of scaffolding, ladders and other equipment for safe work above ground level. All manufacturing is carried on in our own plants under the supervision of experts of long experience. Branch offices and representatives in all major cities assure prompt deliveries and complete scaffolding service.

- **GOLD MEDAL Tubelox Steel Scaffolding**
- **GOLD MEDAL Safety Scaffolding Machines**
- **GOLD MEDAL Junior Safety Swinging Scaffolds**
- **GOLD MEDAL Steel Sidewalk Bridges**
- **GOLD MEDAL Ladders—Wood and Light Metal**
- **"TROUBLE SAVER" Sectional Steel Scaffolds**
- **"TROUBLE SAVER" Steel Scaffold Brackets**
- **"TROUBLE SAVER" Adjustable Steel Trestles**

COMPLETE STOCKS FOR SALE OR LEASE

GOLD MEDAL
LADDERS
SCAFFOLDING

for GREATER SAFETY . . . EFFICIENCY . . . ECONOMY

THE PATENT SCAFFOLDING CO., Inc.

38-21 12th Street **Dept. ENR** **LONG ISLAND CITY 1, NEW YORK**

BRANCH OFFICES: Atlanta • Boston • Chicago • Dallas • Detroit • Kansas City, Mo. • Los Angeles • Miami • Milwaukee • Philadelphia • Pittsburgh • San Francisco • Seattle • St. Louis

ENGINEERS
CONSTRUCTORS

BECHTEL

BUILDERS FOR INDUSTRY

Growing with American Industry—and helping American Industry to grow—Bechtel Corporation enters its second half century of outstanding engineering and construction service.

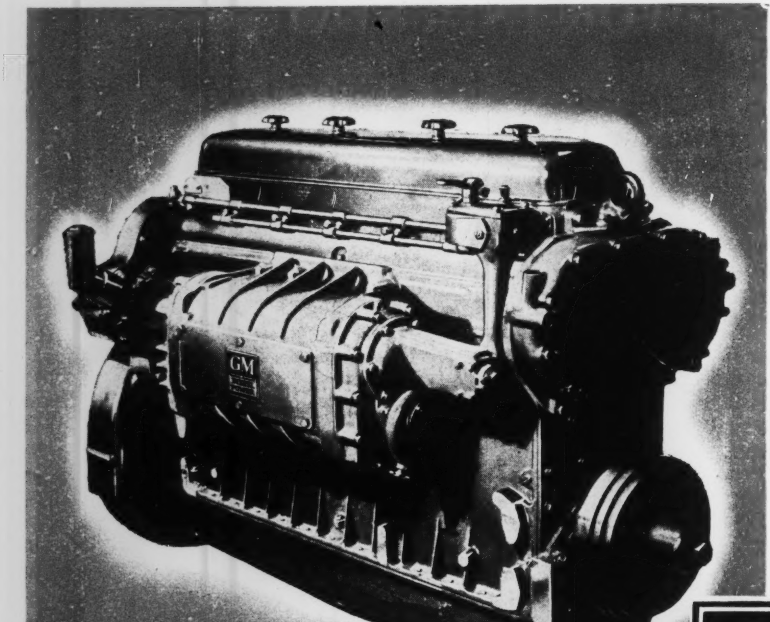
From modest beginnings concentrated in the west alone, expansion has been worldwide. Today, Bechtel planned, Bechtel designed and Bechtel built industrial units are in operation in every quarter of the globe.

Bechtel engineers and construction men are justly proud of their part in effective development of the nation's industrial and natural resources which have created American living standards—highest in world history. To sustain and enhance these standards—while improving the lot of free peoples everywhere—is the vital task to which our energies are dedicated.

SAN FRANCISCO

LOS ANGELES NEW YORK

GREAT FOR FINE



Diesel Brawn Without the Bulk

DETROIT DIESEL ENGINE DIVISION

SINGLE ENGINES . . *Up to 200 H.P.* **DETROIT 28, MICHIGAN** MULTIPLE UNITS . . *Up to 800 H.P.*

GENERAL MOTORS

GM
GENERAL MOTORS
DIESEL POWER

DIESELS EQUIPMENT

Today the list of manufacturers, who offer their contractors equipment powered with General Motors "71" Diesels, reads like a "Who's Who" of the industry. They know what these powerful, modern 2-cycle Diesels can do.

They know that these engines with all their power are compact and fit in available space—that they do their work easily and fast. Their 2-cycle operation makes them responsive and quick to pick up under load. They step up the work done by any kind of equipment.

GM Diesels have been designed for easy servicing. Pistons, liners, valves, and many other parts, are the same for every size Series 71 engine, so there is the maximum interchangeability of parts.

No wonder, then, that America's finest contractors' equipment is being furnished with the General Motors Series 71 Diesel engine.

LEADING MANUFACTURERS OF THE FOLLOWING EQUIPMENT OFFER GM SERIES 71 DIESEL ENGINES IN THEIR PRODUCTS:

Air Compressors
Arc Welders
Asphalt Plants
Buses
Cableways
Cranes
Distillation Equipment
Ditchers
Draglines
Dredges
Earthmoving Loaders
Evaporation Units
Feed Mills
Fire Pumps
Hoists
Industrial Locomotives
Locomotive Cranes
Logging Loaders
Logging Yarders
Mining Pumps
Motor Graders
Off-The-Road Vehicles
Oil Field Equipment
Pavers
Power Scrapers
Pumps
Road Rollers
Rock Crushers
Rotary Soil Tillers
Saw Mills
Screening Plants
Shovels
Soil Stabilizers
Stave Mills
Tractors
Trucks
Wellpoint Pumps

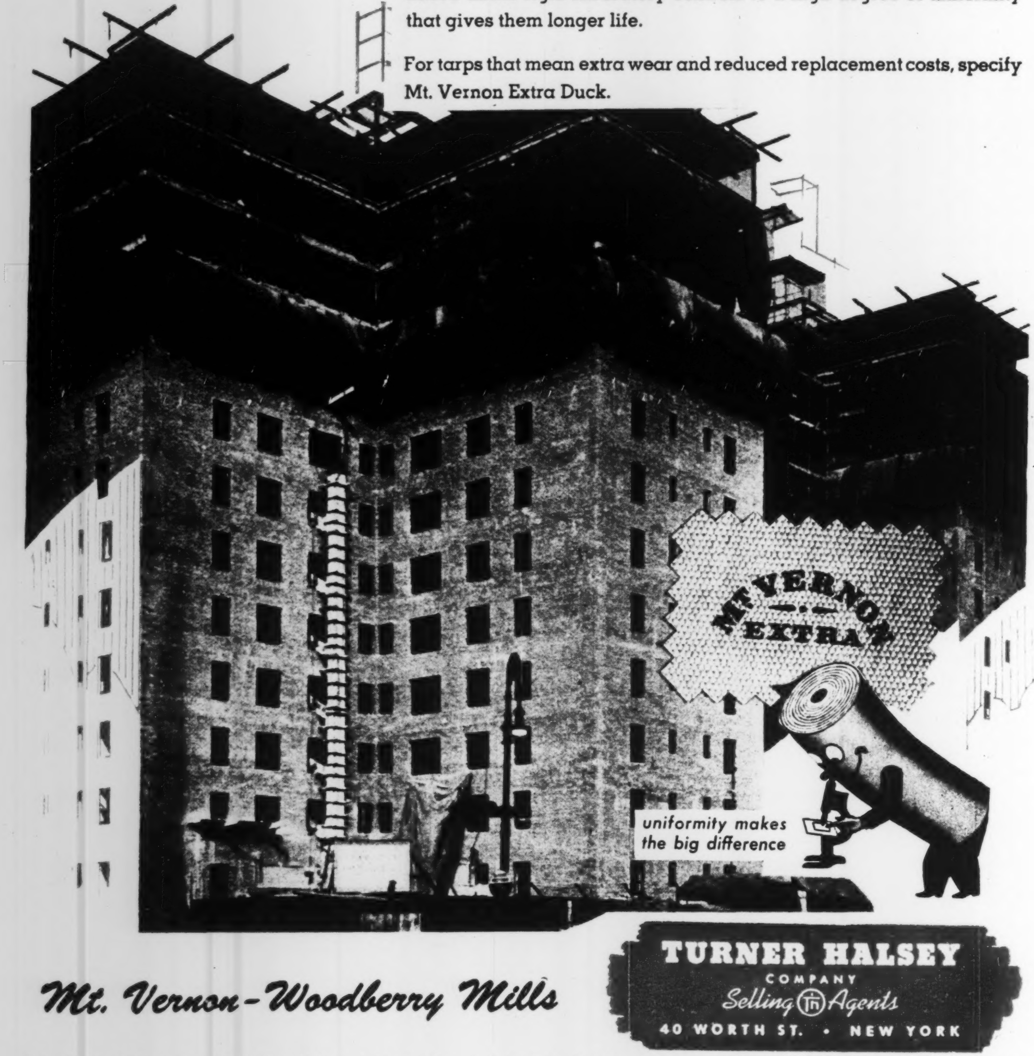
IT'S WISE FOR YOU TO SPECIFY GM DIESEL

Tarps that Help Pay for Themselves

You'll like the way Mt. Vernon Extra cuts your tarp replacement costs. There's longer wear and extra protection with Mt. Vernon Extra even under the most punishing of service conditions.

Mt. Vernon Extra fabrics are made from top grades of cotton and produced under rigid laboratory controls to a high degree of uniformity that gives them longer life.

For tarps that mean extra wear and reduced replacement costs, specify Mt. Vernon Extra Duck.

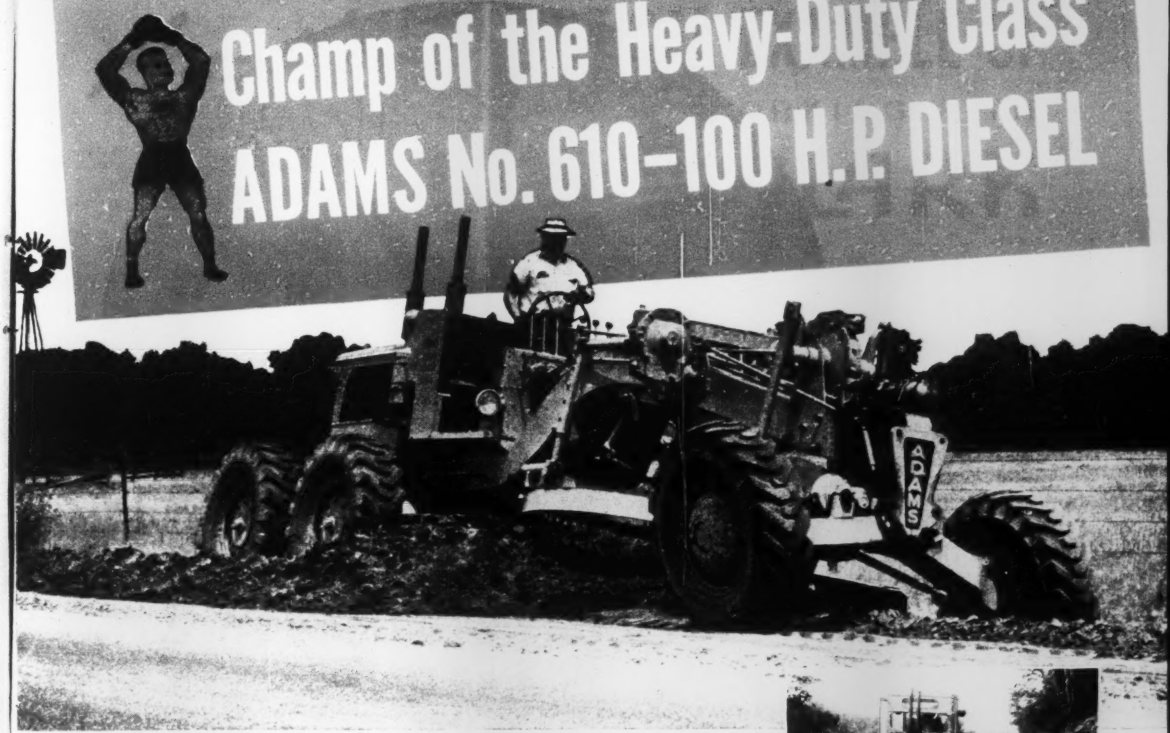

MT VERNON
EXTRA
uniformity makes the big difference

Mt. Vernon-Woodberry Mills

TURNER HALSEY
COMPANY
Selling Agents
40 WORTH ST. • NEW YORK

Branch Offices: CHICAGO • ATLANTA • BALTIMORE • BOSTON • LOS ANGELES • AKRON

Champ of the Heavy-Duty Class
ADAMS No. 610–100 H.P. DIESEL



▲ Banksloping rocky mountain side

▼ Scarifying limestone road base

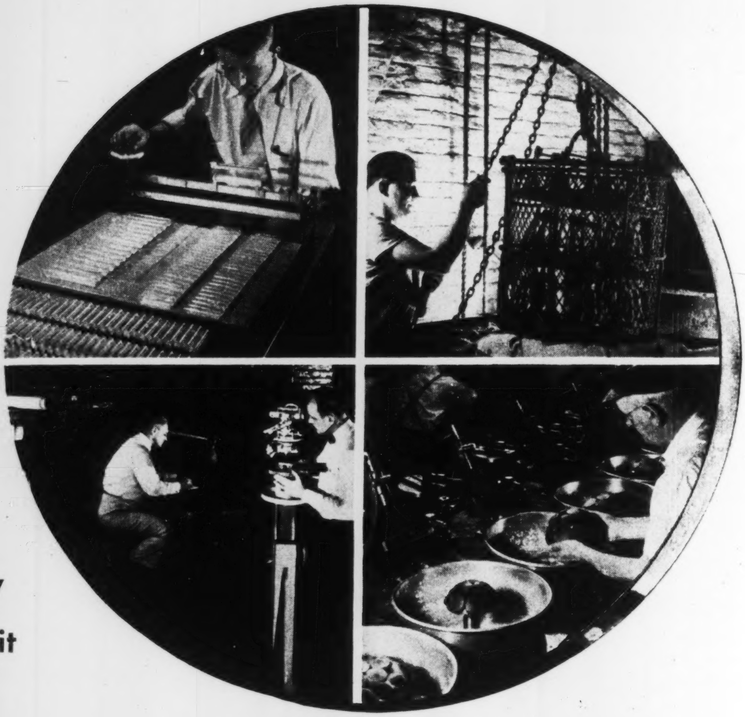
Only the Adams No. 610 Offers All These Features

- 100 H.P. Full-Diesel Engine—6-cylinder—powerful, dependable.
- Weight—up to 27,000 lbs. Plenty to utilize all h.p.—*in all gears.*
- Push-Button Starting from the cab—standard equipment.
- Power Steering—standard equipment. Mechanical-hydraulic type—all advantages of mechanical steering, with power doing the work.
- Powerful 4-Wheel Hydraulic Brakes on tandem—fast, easy stops.
- Large, Wide-Tread Tires (14.00-24 rear, 11.00-24 front). Adequate traction and flotation for every type of grader operation.
- 8 Overlapping Forward Speeds, 2 reverse. Transport speed of 25 mph.
- Extra Wide Blade (28 in.) to utilize No. 610's great capacity.

The Adams No. 610 is a husky extra-heavy-duty machine, through and through—not a "souped-up" lighter model. Specially designed to utilize the full torque of its big 100 H.P. engine—*in all gears*—it handles heaviest work easily—accomplishes more work per day . . . all at lowest possible cost. Let your local Adams dealer tell you about this great new grader.

J. D. ADAMS MANUFACTURING CO. · INDIANAPOLIS, INDIANA

Make your next motor grader an **ADAMS**



Take a look at what's behind every Gurley Transit

From first castings to final calibration—every step in the manufacture of Gurley transits is focused on accuracy—both in the production of each individual part and their combined performance in the field. That's why—

Spirit levels are reversion type—ground to barrel shape in Gurley-designed machines for sensitive, accurate performance without distortion. Graduations are precisely matched and etched on opposite sides. Vials are truly circular at any cross-section—assure identical reverse readings.

Gurley transits are durable—but lightweight, too. They won't distort with age. Parts are heat-treated, hardened and tempered as required. Special bearing metals are cast integral with sturdy parts and can't shake loose. They're aluminum for easy carrying, anodized and dyed to prevent corrosion and tarnishing.

Collimating methods which duplicate first order outdoor observing programs without weather uncertainties are used to calibrate assembled Gurley transits. These facilities are equivalent to those used by the U. S. Coast and Geodetic Survey. Here *"20 second" transits are calibrated to approximately one second.*

Gurley telescopes reach maximum optical power. All lenses are Gurley-made in our completely equipped optical department, tested under helium light for conformity to a master test plate. They're coated, too, if desired, in the latest-type lens coating machines.

These are some of the things you see when you take a look at what's behind a Gurley transit—the result of over a century of fine instrument-making experience at work in a completely self-contained, modern manufacturing plant—under field-seasoned engineers. They are the reasons, too, why every Gurley transit is backed-up by an unqualified guarantee.

For complete details, write for Bulletin 50.

W. & L. E. GURLEY, UNION PLAZA, TROY, NEW YORK

Surveying and Engineering Instruments, Hydraulic Engineering Instruments, Standard Precision Weights and Measures, Paper and Textile Testing Instruments, Aeronautical Navigating Instruments, Meteorological Instruments, Reticle Making Facilities.

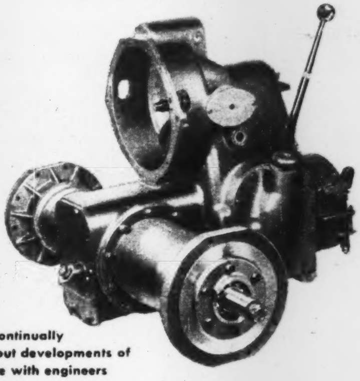
GURLEY

Surveying and Scientific Instrument Makers
Since 1845

Another PRACTICAL EXAMPLE OF INDUSTRY WORKING WITH CLARK

THE PROVED working combination of Industry and Clark has done it again! Planning . . . designing . . . engineering together, this time-tested team has developed a thoroughly practical drive unit for the Allis-Chalmers Model "B" Road Grader.

Both the manufacturer and Clark concentrated their broad engineering experience on one objective—*to develop a simple, rugged drive unit, wholly functional in design, for a truly modern Grader, to be unsurpassed in its field.* In this instance, as in many others, the result was almost inevitable . . . a better unit, improved equipment —thanks again to the formula of Industry working with Clark.



Clark is continually working out developments of this nature with engineers of machinery manufacturers—in both the Agricultural and Industrial fields. When you are confronted with transmission or axle design application problems, you too will find Clark ready to help.

CLARK EQUIPMENT COMPANY, BUCHANAN, MICHIGAN

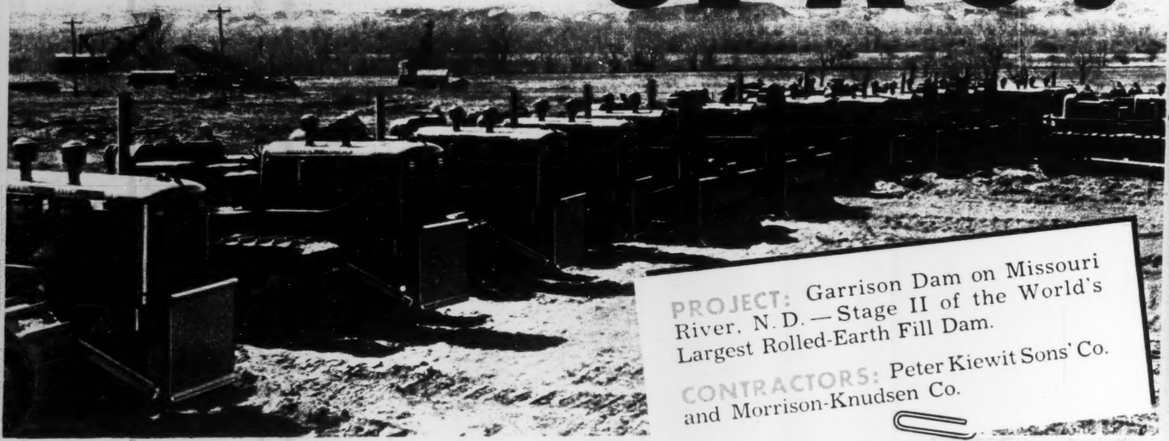
OTHER PLANTS: BATTLE CREEK, JACKSON, BERRIEN SPRINGS, MICHIGAN

PRODUCTS OF CLARK — TRANSMISSIONS · FORK TRUCKS & TRACTORS · AXLE HOUSINGS

GEARS AND FORGINGS · RAILWAY CAR TRUCKS · ELECTRIC STEEL CASTINGS

FRONT AND REAR AXLES FOR TRUCKS AND BUSSES · METAL SPOKE WHEELS · TRACTOR UNITS

FLEETS OF A-C's



PROJECT: Garrison Dam on Missouri River, N. D. — Stage II of the World's Largest Rolled-Earth Fill Dam.

CONTRACTORS: Peter Kiewit Sons' Co. and Morrison-Knudsen Co.

42 HD-19 HYDRAULIC TORQUE CONVERTER TRACTORS

PULL and PUSH BIG LOADERS (right) — Heavy, powerful HD-19's keep big loaders operating at capacity in the tough going. Synchronize speeds — start and stop with throttle . . . no constant clutching. Spillage is negligible, there's less wear and tear on loader and tractors.

BOOST HAULING UNITS — HD-19's with pusher plates, "patrol" the job . . . keep the heavily loaded wagons moving through the mucky material. Catch them quickly, make a smooth contact and stay with 'em — match speeds exactly.

HANDLE ALL TYPES OF BULLDOZING (right) — Fleets of '19's, with matched 'dozers, are everywhere, speeding up every job — clearing, leveling fills, cleaning up around shovels, sloping, building haul roads, pulling equipment. High reverse — to 5.5 m.p.h. No worrying about overloads — can't kill engine.

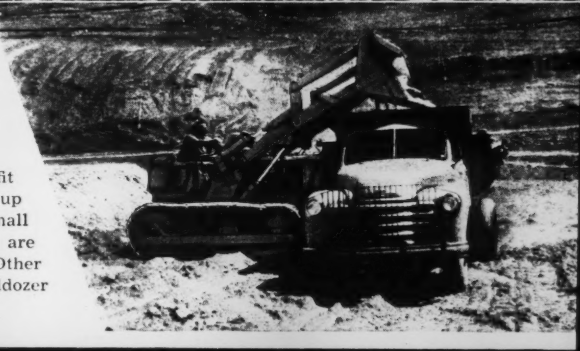
PULL SCRAPERS, ROLLERS, OTHER EQUIPMENT — Big, sure-footed, better-balanced HD-19's really bear down and lug on every hauling job. Automatically move equipment as fast as load and ground conditions permit — up to 3.0 m.p.h. in low, to 7.0 m.p.h. in high.

help rush big job

12 MODEL AD MOTOR GRADERS

KEEP HAUL ROADS SMOOTH — A continuous procession of big hauling units tear, whip and grind the earth as they travel. Keeping the way smooth, to keep the material moving fast, is the job assigned to the fleet of A-C Motor Graders . . . plus cutting and sloping banks. Strong, powerful, fast, diesel-powered Allis-Chalmers Motor Graders can "take on" the toughest jobs, handle them smoothly, quickly, at lowest possible cost. Only A-C Motor Graders have the "Roll-Away" Moldboard — less power required to move more material at faster speeds.

HD-5 WITH TRACTO-SHOVEL



VERSATILE — There's no limit to the applications of this outfit with its many interchangeable attachments. Here it picks up oversize rock from the fill with specially designed forks. Small stones go through the forks, the big ones remain — and are loaded into trucks. Think of the savings on man-hours! Other attachments include various sizes and types of buckets, bulldozer blades and a "V" snowplow.

ALLIS-CHALMERS

...Originator of the Torque Converter Tractor

TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

THROUGH THE YEARS

and Today...

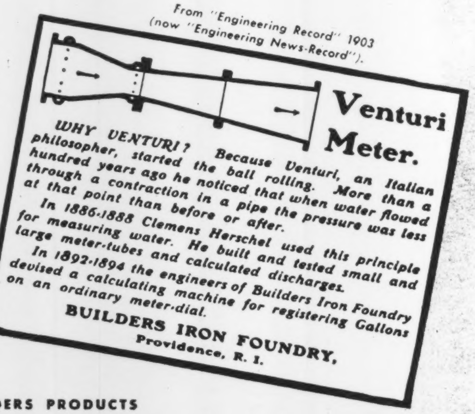
BUILDERS Venturi METER

THE STANDARD FOR ACCURATE METERING

For more than half a century the Builders Venturi Meter has been recognized as the standard for measuring flow of water, sewage, and air in main pipe lines. Both the Venturi Tube installed in the line and the Type M Register-Indicator-Recorder Instrument connected to the Tube are built for lifelong accuracy. There are no moving parts in the pipe line — nothing to wear out. After two generations many Venturi Meters are still in service, operating with original precision and efficiency. For Bulletins and engineering information, address Builders-Providence, Inc., (Division of Builders Iron Foundry), Providence 1, R. I.

Even last century the Builders Venturi Meter was widely advertised and well known for its high accuracy — it remains today the *Standard* wherever flows must be accurately and economically metered.

From "Engineering Record" 1903 (now "Engineering News-Record").



Venturi Meter.

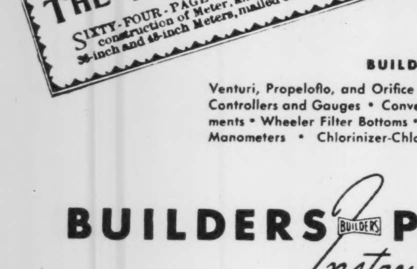
WHY VENTURI? Because Venturi, an Italian philosopher, started the ball rolling. More than a hundred years ago he noticed that when water flowed through a contraction in a pipe the pressure was less at that point than before or after.

In 1886-1888 Clemens Herschel used this principle for measuring water. He built and tested small and large meter-tubes and calculated discharges.

In 1892-1894 the engineers of Builders Iron Foundry devised a calculating machine for registering Gallons on an ordinary meter-dial.

BUILDERS IRON FOUNDRY,
Providence, R. I.

From "Engineering Record" 1894 (now "Engineering News-Record").



BUILDERS IRON FOUNDRY,
PROVIDENCE, R. I.

THE VENTURI METER.

SIXTY-FOUR-PAGE PAMPHLET, describing construction of Meter, and records of tests of 36-inch and 48-inch Meters, mailed on application.

BUILDERS PRODUCTS

Venturi, Propeloflo, and Orifice Meters • Kennison Nozzles • Venturi Filter Controllers and Gauges • Conveyoflo Meters • Type M and Flo-Watch Instruments • Wheeler Filter Bottoms • Master Controllers • Filter Operating Tables Manometers • Chlorinizer-Chlorine Gas Feeders • Chronoflo Telemeters

BUILDERS PROVIDENCE Instruments

IT'S ALL THE SAME TO A BAKER BULLDOZER

Any job...*any* condition a Baker Bulldozer takes it in stride. There's built-in brute strength for the toughest going; fast acting, simplified hydraulic control; positive down pressure; plus perfect balance that utilizes every ounce of tractor power. No wonder Baker Bulldozers and Gradebuilders teamed up with Allis-Chalmers tractors are rated the top bulldozing team in the business.

• • •

It's an all weather — all year round team that turns low margin jobs into profitable ones — it's a versatile team that pays for itself on any job. Get the complete facts from your friendly Baker — Allis-Chalmers dealer today.

They Go Together!

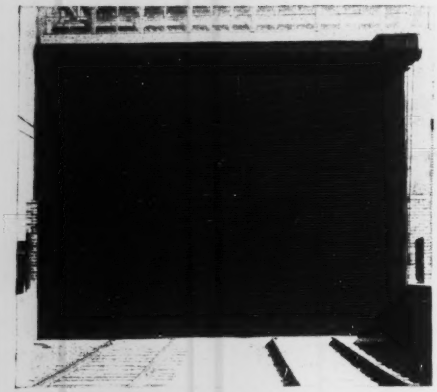
BAKER

SPRINGFIELD, ILLINOIS

Rolling Steel

DOORS

Manually • Mechanically • Power Operated



RAILROAD OPENINGS

Rolling Steel Doors are ideal for Railroad Openings in Industrial Plants, Warehouses, etc. These doors can be furnished for openings accommodating one, two, or three parallel tracks. You may select from Two Types of Mahon Power Operators and several control arrangements.

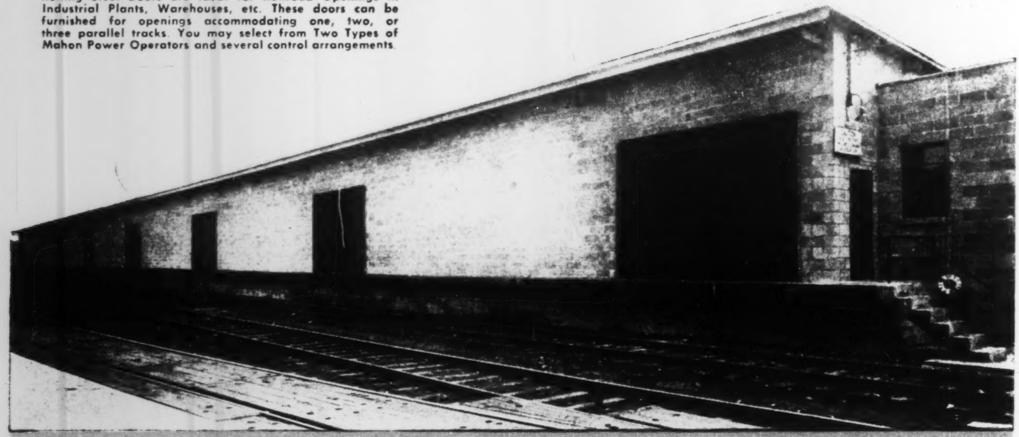
Vertically acting Rolling Steel Doors allow 100% usable space adjacent to the door opening . . . they coil up clear of the opening safe from damage while the opening is in use . . . they provide the maximum in protection against intrusion and fire—and the permanence of all steel construction assures a lifetime of trouble-free service. When you specify Mahon Rolling Steel Doors, you may be confident of the latest developments in doors of this type, and a greater dollar value. See Sweet's Files for detailed information, complete specifications, installation details and clearance dimensions.

THE R. C. MAHON COMPANY

Detroit 11, Michigan • Western Sales Division, Chicago 4, Illinois

Representatives in All Principal Cities

Manufacturers of Rolling Steel Doors, Grilles, and Underwriters' Labeled Rolling Steel Doors and Fire Shutters. Mahon Steel Deck for Roofs, Partitions, Acoustical Ceilings, and Permanent Floor Forms.



ROLLING STEEL DOORS, SHUTTERS AND GRILLES TO MEET EVERY REQUIREMENT

Thirty Mahon Rolling Steel Doors are installed in the above freight transfer dock constructed for the Wabash Railroad.

MAHON

INSULATED STEEL WALLS

and STEEL DECK ROOFS

for INDUSTRIAL and COMMERCIAL BUILDINGS

Mahon Insulated Steel Walls are ideally suited for industrial and commercial buildimgs, and for many special purpose structures, such as power houses and transformer stations, where high expanses of wall are encountered. Walls up to sixty feet in height may be constructed without horizontal joints . . . this feature alone has found favor with many architects throughout the country. Vertical ribs are six inches on centers on the outside of the wall with interlocking ribs one foot on centers. The inside surface of the wall is smooth, with vertical interlocking joints one foot on centers. This type of wall construction in combination with a Mahon Steel Deck Roof costs less, provides a firesafe, permanent building which can be quickly and economically erected. See Sweet's File for complete information.

THE R. C. MAHON COMPANY

Detroit 11, Michigan • Chicago 4, Illinois

Representatives in all Principal Cities

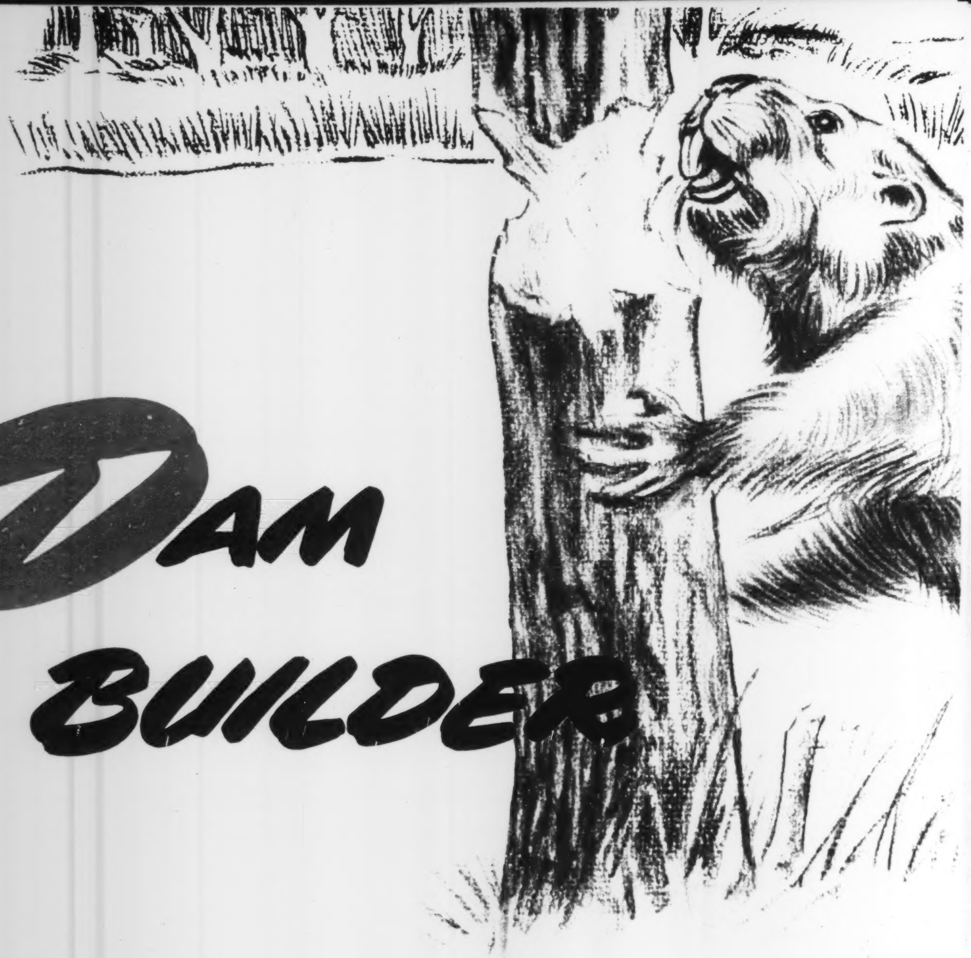
Manufacturers of Insulated Steel Walls, Steel Deck for Roofs, Ceilings, Floors and Partitions. Rolling Steel Doors, Grilles, and Underwriters' Labeled Rolling Steel Doors and Fire Shutters.

FIELD CONSTRUCTED
PREFABRICATED PANELS
DETAILS
CONSTRUCTION DETAILS

CONSTRUCTION DETAILS
Scale 3" = 1'-0" Suitable for tracing
WILL BE MAILED ON REQUEST

A typical building constructed with Mahon Insulated Steel Walls throughout, and Mahon Steel Deck Roof. Note pilaster effect obtainable in walls.

MAHON



DAM BUILDER

Matchless ability to hang on to a load and put dirt where you want it *fast*—that's the kind of performance you get from International Diesel Crawlers on any earthmoving job. *Built to outperform,* to dig in and do, with diesel power that *exceeds* today's exacting requirements!

Quick to get to work; with in-built, all-weather starting—and quick to do the work; with 8 speeds ahead, 8 in reverse and finger-tip speed and steering control—International TD-24 turns in record after record of unbeatable work performance.

On dams for soil conservation as well as the great flood-control and hydro-power earthworks, this modern, diesel crawler is the tractor to use for all your tough jobs. Contact your International Industrial Power Distributor for TD-24's now.

INTERNATIONAL HARVESTER COMPANY
CHICAGO

Write for your copy of the TD-24 catalog

Standardize on Power that Pays

CRAWLER TRACTORS • WHEEL TRACTORS • DIESEL ENGINES • POWER UNITS

This International TD-24, with 140 horsepower at the drawbar, delivers a bladeful of heavy clay with ease and precision at the crest of an earth dam in Illinois. Increase your work capacity with a TD-24.

INTERNATIONAL
HARVESTER

INTERNATIONAL
INDUSTRIAL POWER

Cut costs with the rope that lasts longest

Contractors are saving with Preformed "Blue Center" Wire Rope

WHEN YOU ASK "HOW LONG," don't think merely of a rope's length; think of how long it will stay on the job! The rope that lasts longest, costs you the least . . . and that's why contractors are turning to Roebling Preformed "Blue Center" Steel Wire Rope. "Blue Center" Steel—made only by Roebling—gives wire rope *extra* ability to withstand strain, abrasion and shock loads.

PREFORMED SPEEDS OPERATIONS, TOO. Roebling Preformed saves handling and installation time because it is not inclined to set or kink. You can cut it without seizing, and there's less trouble in applying fittings. In operation, Preformed is largely free of vibration and whipping . . . gives top performance despite severe bending, small sheaves and reverse bends.

FREE ENGINEERING SERVICE. Have your Roebling Distributor help choose the *right* wire rope for genuine economy on your equipment. If you have any special problems in the selection, installation or maintenance of wire rope, your Distributor will promptly get the assistance of a Roebling Engineer. John A. Roebling's Sons Company, Trenton 2, New Jersey.

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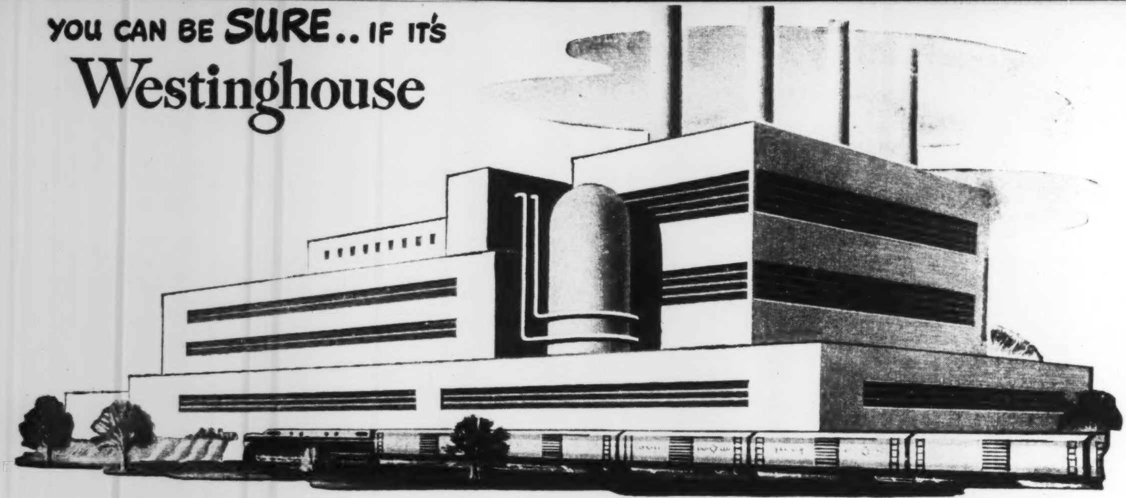
Westinghouse



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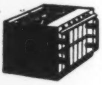
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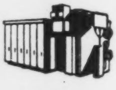
Unit Substations

Panelboards

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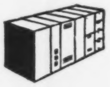
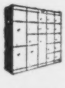
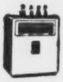
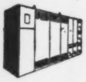
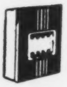

Ignitron Unit Substations

Safety Switches


Control Centers

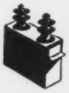

Dry Type Transformers


Power Centers


Load Centers

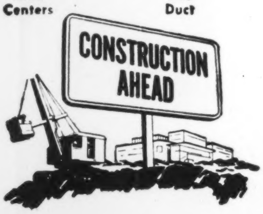
Bus Duct

Power Transformers


Capacitors

Mechanical Drive Turbines

AB-1 Circuit Breakers



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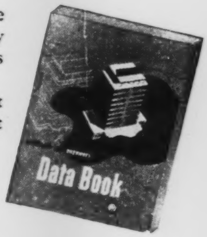
This 362-page book contains detailed information on Westinghouse products for the Construction Industry. It was designed specifically to meet the requirements outlined by Architects and Engineers themselves.

Industry-wide distribution has already been made. If you do not already have your copy, ask your nearest Westinghouse District Office to send you B-2161-D.



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Quality Construction at Substantial Savings with

CONCRETE FRAMES AND FLOORS

CONCRETE frame and floor construction is ideally adapted to hospitals, apartments, schools, hotels, industrial plants and office buildings. It offers three important advantages of paramount interest to architects, engineers, owners and taxpayers:

1. It provides quality construction.
2. It substantially reduces construction costs.
3. It requires less construction time.

Competitive bidding repeatedly has shown that concrete frames and floors can effect big savings in construction costs. Such savings are possible in tall buildings or in structures of six stories or less.

Maximum savings from concrete frame and floor construction can be achieved by observing the time-tested, easy-to-follow principles of quality concrete construction. This means designing the correct mix for the job, selecting the right materials for the mix, placing the mixture properly and curing the concrete adequately.

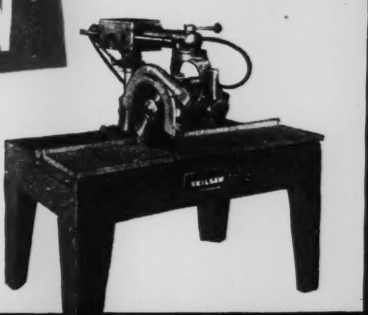
Applying the principles of quality concrete construction results in a mix that makes economical use of available materials, that is workable enough to be placed easily and quickly and that when hardened produces concrete with the strength to resist all static and dynamic loads.

For help in designing quality concrete write for a free copy of a 70-page illustrated booklet, *"Design and Control of Concrete Mixtures."* Booklet distributed only in United States and Canada.

Photo shows construction of Veterans Administration Hospital, Wilkes-Barre, Pa. The design utilizes reinforced concrete frame and concrete joist floors with concrete masonry fillers. The structure is approximately 46 ft. x 420 ft. and is 11 stories high. Kelly & Gruzer and Isadore Rosenfield, architects; Fred Severud, consulting engineer; and Merritt-Chapman & Scott Corporation, contractor, all of New York City.

PORTLAND CEMENT ASSOCIATION
DEPT. A9a-17, 33 WEST GRAND AVENUE, CHICAGO 10, ILLINOIS
A national organization to improve and extend the uses of portland cement and concrete through scientific research and engineering field work

Here's why **Radial SKIL Saw** is your best bet for fast...precise ...high-production sawing!

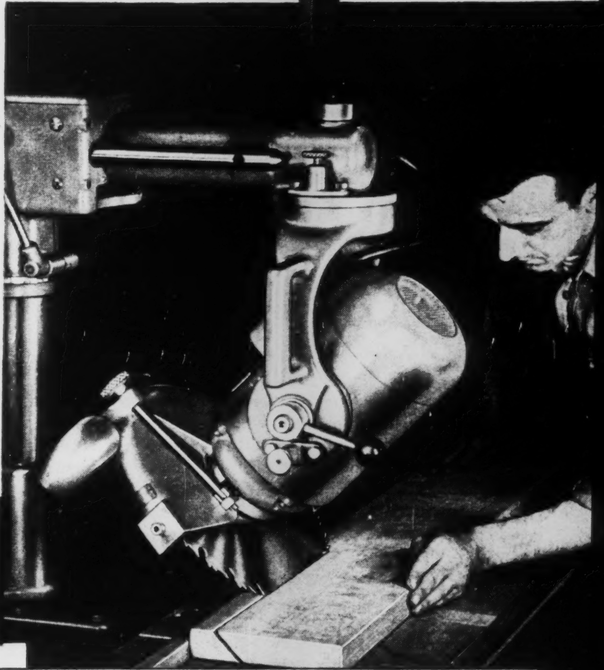


Exclusive *RETRACTABLE ARM!*

DOZENS OF SUPERIOR FEATURES!

Radial SKIL Saw is tops . . . for speed . . . for precision . . . for ease of operation. Finger-Tip control . . . quick, simple adjustments (all made from the front) . . . constant accuracy and precision! They're all yours with this better tool!

Look at its features! Everything about Radial SKIL Saw adds up to peak production . . . finest performance . . . lowest maintenance costs and long service. Ask your SKIL Tool Distributor to demonstrate Radial SKIL Saw today!



ALL THESE SUPERIOR DETAILS SAVE STEPS...SAVE TIME... SAVE MONEY FOR YOU!

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- **Slides freely** on double-row ball bearings!
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- **More room for job set-ups** because sawing head moves out of the way!
- **Clear-view sawing** with layout marks always in sight!

FRONT ADJUSTMENT OF ALL CONTROLS

- Retractable elevator handle in front.
- Quick adjustments for all cuts without leaving operating position.

DOZENS OF SPECIAL FEATURES

- One-piece saw guard . . . easy to remove without tools.
- Plunger pin locks for rapid adjustment of sawing head.
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- Flexibility to make all compound cuts.
- Ripping scale mounted on arm for accurate measurement.
- Tapered wedge lock for fast, precise location of straight and both right and left 45° cut-offs.
- Enclosed dustproof motor.
- Unique design.
- Finest engineering.
- Top quality workmanship and materials.

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One-Man "D" ROADSTER

Roy Jones

COMPLETES a DAM a DAY with 25 m.p.h. D ROADSTER

"Just the thing for soil conservation stockpond dams," says Roy Jones, who has been using a high-speed D Roadster to build a series of small-yardage dams throughout Edmunds County, South Dakota. Each assignment averages 1500 cu. yds. . . . and is usually completed in one day. Here's typical performance:

2-minute cycles on 200′ one-way haul

In one 10-hour day, Jones filled 1500 cu. yds. of sun-baked sandy clay and gravel across a gully, near Beebe, S.D. To pioneer the initial fill, operator used the D Roadster's Dozer blade to backfill and spread the first few loads in the gully bottom . . . then started hauling in Scraper loads at a rate of a load every 2 minutes! Cycle time included 51 seconds to self-load 5 yards, and 12 seconds to spread. Haul was extremely short . . . averaged about 200′ one-way, because material was borrowed as close as possible along both sides of the dam.

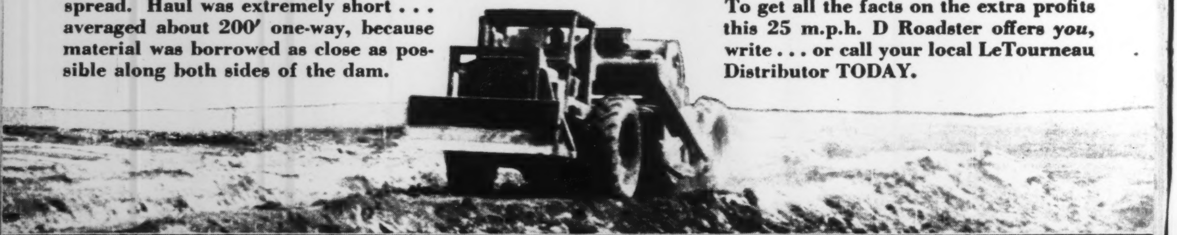
Drive job-to-job

Jones estimated he had a schedule of at least 4 to 6 weeks of these 1-day soil conservation dams booked ahead . . . then planned to switch his high-speed Roadster to township road work. On this fast "work-and-run" schedule, the rubber-tired Roadster's 25 m.p.h. speed really pays off. One job completed, operator drives off to the next day's assignment. There is no waiting for trailer . . . no loading delays . . . less non-productive time between jobs with this high-speed rig.

Versatile Scraper-Dozer tool

As a one-man Scraper dirtmoving tool, this fast, mobile Roadster has gained wide acceptance on stockpond work, road maintenance and other small contract operations. Now, with Dozer blade on front, the "D's" usefulness is doubled. Handles backfilling, light clearing . . . push-loads other "D's" in fleet operation. You'll find it the handiest Scraper-Dozer combination you've ever seen.

To get all the facts on the extra profits this 25 m.p.h. D Roadster offers *you*, write . . . or call your local LeTourneau Distributor TODAY.



Mail Today **for complete information to: R. G. LeTOURNEAU, Inc., Peoria, Ill.**

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Please send ☐ Specifications ☐ Price ☐ Delivery information on 25 m.p.h. D Roadster

NAME.. TITLE....................................

COMPANY..

STREET.. CITY, STATE....................................

Type of work to be handled..

earns extra profits ON STOCKPOND DAMS

With 7-yard (9-ton) capacity Scraper, and handy Dozer blade, this 100 h.p. D Roadster has proved itself a profitable "one-man dirtmoving gang" for Contractor Roy Jones, who is specializing on stockpond dam construction in Edmunds County, South Dakota.

C. H. Wilhelm moved 125 yds. per hour over 400′ haul on Faulkton, S. D. dam

On a soil conservation dam in Faulk County, S. D., Contractor C. H. Wilhelm found his rubber-tired "D" made 5 to 10 more trips per hour than 2 crawler-scraper outfits on the job. Haul was short . . . 300 to 400′ . . . round trip varied from 800 to 900′. On an actual 60-min. load count, one 91 h.p. crawler made 17.4 trips . . . and a 101 h.p. crawler made only 12.6 loads . . . moved 88 and 139 yards per hour respectively. Wilhelm's self-loading Roadster (costing approx. 20% less than either of the 2 crawler-scraper rigs) delivered 22.9 loads . . . averaged 125 yards per hour.

Loren McLaury built 1600-yard dam in 19½ hours with D Roadster

In Douglas County, South Dakota, Contractor Loren McLaury of Parkston turned in this yardage performance on an earthfill dam for the AAA: His one-man D Roadster excavated the core trench in 2½ hours . . . then completed the 1600-yard fill in just 17 hours. Total job time: 19½ hours! Material, black loam and clay, was self-loaded. Average cycle was 800′. Production for the entire job averaged 94 cubic yards per hour. McLaury's operator drove the highly-mobile, rubber-tired "D" into the job, near Corsica, over county and state roads . . . drove on to next job after work was completed.

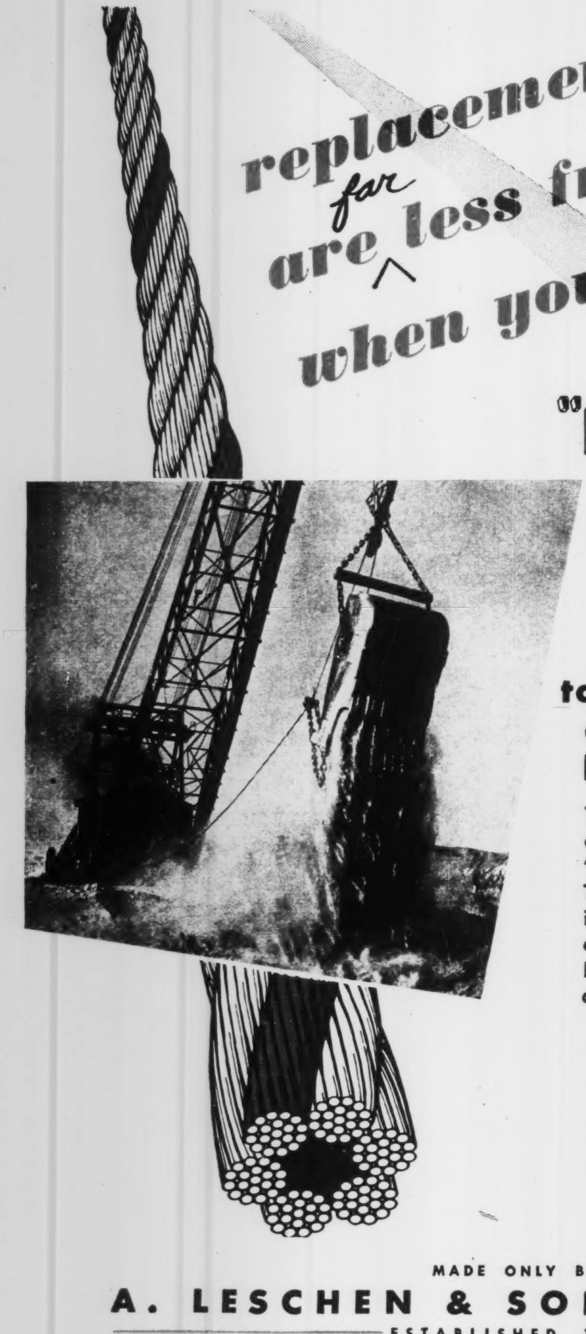
Tournapull—Trademark Reg. U.S. Pat. Off. C121

LETOURNEAU
PEORIA, ILLINOIS

JOB-PROVED
Over 6250 Built and Shipped

TOURNAPULLS

MORE WORK PER HOUR WITH RUBBER-TIRED POWER



replacements are far less frequent when you use

-Preformed-

"HERCULES"

REG. U.S. PAT. OFF.

RED-STRAND

WIRE ROPE

because—

Its strength . . . its toughness . . . its unusual endurance—add up to longer wire rope life

These essential life factors are not a matter of chance. They are the result of combining "HERCULES" quality and PREFORMING. This is a winning combination as Preforming is the process that increases the life of a wire rope, by freeing it of internal stresses. It also makes a wire rope easier, quicker and safer to handle.

"HERCULES"
RED-STRAND
the **DEPENDABLE**
WIRE ROPE
for any **TOUGH JOB**
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VACUUM CONCRETE

An Invitation to Look into America's Building Future

. . . TODAY

After just one *night* a pre-cast vacuum slab is removed from its form by a Vacuum Lifter . . . this is just one of the many construction miracles Vacuum Concrete offers to increase the efficiency and profit of concrete construction.

"IT WINS CONTRACTS"

Contractors and Architects all over the world are discovering how practical it is to use Vacuum Concrete. For the builder, its downright economy is a big factor . . . it wins contracts. The architect specifies it for its endurance and adaptability. We are thoroughly proud of our product . . . the tools that process this concrete. On these pages we present for your information what Vacuum Concrete means to America's building future . . . what it can mean to your own future in the construction business.

K. P. Billner **President**

VACUUM CONCRETE INC.

(Inventor of the Vacuum Concrete Processes)

VACUUM CONCRETE PROCESS

NEW SPEED • NEW STRENGTH • NEW SURFACE

NEW ECONOMY!

SPEED...... High early strength . . . early stripping of forms . . . less finishing . . . larger daily pours . . . reduction of winter weather delays.

STRENGTH.. Makes concrete from 40% to 250% stronger, depending on the mix . . . cuts shrinkage to a minimum thus eliminating main cause of cracks . . . helps resist effects of freezing and thawing cycles.

SURFACE.... Extreme resistance to abrasion is main characteristic of surface . . . used by U. S. Engineers and Bureau of Reclamation on important dams . . . found ideal for road surfacing . . . specified by major cities for sewer pipe.

ECONOMY... For certain types of vertical construction Vacuum Concrete can use incredibly lean mixes such as one part cement to sixteen parts aggregates . . . gives strength of 3000 pounds per square inch with this mix . . . reduces finishing time . . . eliminates finisher's overtime . . . cuts weather delays . . . lowers placing costs if more convenient to use a wetter mix.

NEW PROCESSES • NEW TOOLS

The actual advantages of speed, strength and economy in concrete construction are accomplished by revolutionary yet simple processes and tools.

For example, vertical Vacuum Forms can be held together by atmospheric pressure. After concrete has been poured in the regular fashion a twist of a valve creates a vacuum around the poured concrete, compressing the mass and leading off the excess moisture. In one hour or less the forms may be released and stripped simply by closing a valve in the vacuum line.

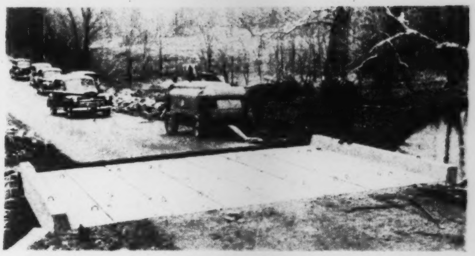
When the concrete has set, the Vacuum Concrete Lifter, pictured on the previous page, attaches itself like an octopus over a large area. There are no point stresses and therefore no extra reinforcement is needed. Large, thin slabs, straight or curved, can be lifted directly from a mold.

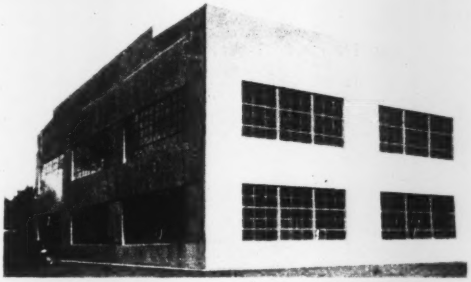
This means that floor slabs, beams, columns, entire roof slabs, bridge decks and many other pre-cast elements, can be lifted after just one night's setting. With these methods daily output of pre-cast members can be more than doubled.

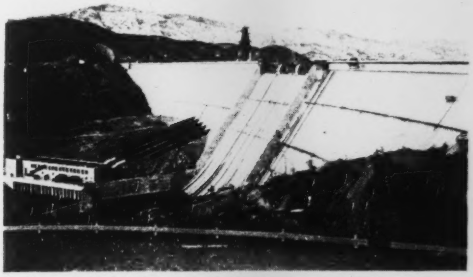
That's what we mean by the building techniques of the *future* available to you . . . *today*.

VACUUM CONCRETE PROCESS

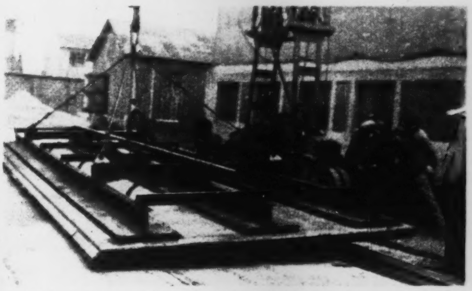
This is a Vacuum Concrete pipe, just four hours old. The Concrete Products Company of America, in Philadelphia, is manufacturing these pipes in lengths up to 12 feet. The vacuum forms are removed in 20 minutes.

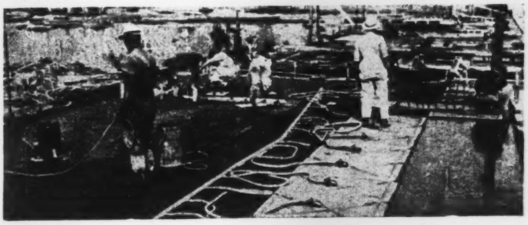

This is the first of a series of pre-cast Vacuum Concrete bridges. It was erected for the Pennsylvania State Highway Commission in three hours at a cost which was 40% below the low bid for a "Cast-in-place" bridge.


One of the many large structures built with pre-cast Vacuum Concrete "Sandwich Walls", insulated with Pittsburgh-Corning Foam-glass, is the Cocheco Woolen Mfg. Co. plant in East Rochester, N. H.


The spillways and apron of Shasta Dam, California, were Vacuum Processed to produce an abrasion-resistant surface. The U. S. Bureau of Reclamation and the Army Corps of Engineers have consistently specified Vacuum Concrete on dams.

The Pentagon Building in Washington, shown above, had to be built in a hurry. This is why four million square feet of floor area were Vacuum Processed.


This is a pre-cast slab 30′ x 10′ x 4″ lifted at the age of 8 hours. About 20,000 such slabs (six million square feet) are to be used for lining the Ottmarscheim Canal in France.


Pictured here is a typical Vacuum Concrete "poured-in-place" operation. The power float is applied after 10 minutes of vacuum processing.

VACUUM CONCRETE PROCESS

TESTS *PROVE* VACUUM CONCRETE IS BETTER

COMPARATIVE COMPRESSIVE STRENGTHS OF PLAIN AND VACUUM PROCESSED CONCRETES

Tests of 6 x 12 cylinders made by E. L. Conwell Laboratories, Philadelphia, Pa.

MIX "A"—4½ SACKS CEMENT—6" SLUMP

	PLAIN CONCRETE	VACUUM CONCRETE	PERCENT OF INCREASE
1 DAY	127 p.s.i.	433 p.s.i.	241%
3 DAYS	673	1612	140%
7 DAYS	1280	2398	87%
28 DAYS	2763	4015	45%
6 MONTHS	3028	4798	58%
1 YEAR	3058	4957	62%

MIX "B"—6 SACKS CEMENT—3" SLUMP

	PLAIN CONCRETE	VACUUM CONCRETE	PERCENT OF INCREASE
1 DAY	320 p.s.i.	637 p.s.i.	99%
3 DAYS	1260	2180	73%
7 DAYS	2217	3513	58%
28 DAYS	3813	5023	32%
6 MONTHS	4913	6255	27%
1 YEAR	5097	6618	30%

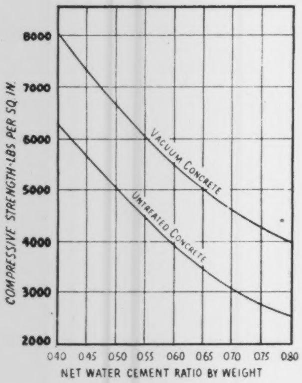
Mix "A"—Approximately 5 to 5½ sacks are usually required for this class of concrete when the Vacuum Process is not used.

Mix "B"—represents a mixture for heavy duty use where exposure is a factor, such as highways, where approximately 7 sacks of cement per cubic yard of concrete are normally used without the Vacuum Process.

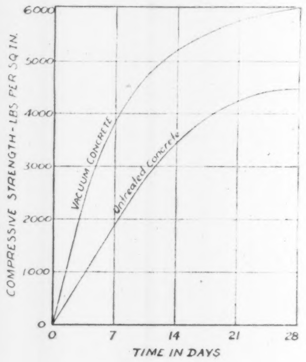
MIX "C" (for walls)—1 PART H. E. CEMENT TO 16 PARTS AGGREGATE

	PLAIN CONCRETE	VACUUM CONCRETE	PERCENT OF INCREASE
1 DAY	135 p.s.i.	613 p.s.i.	454.07%
3 DAYS	533	2093	392.68%
7 DAYS	825	2743	332.48%

SPEAKING GRAPHICALLY



The chart on the left indicates the increased strength of Vacuum Processed Concrete based on initial water-cement ratio. The chart on the right shows the increased strength of Vacuum Processed Concrete based on time in days.



IT ALL ADDS UP

Exhaustive tests over twelve years of constant usage have proven that Vacuum Processed Concrete offers all the advantages highlighted here plus many others. Because of these advantages Vacuum Concrete Construction is now spreading around the World.

We are not contractors. Our function is to supply—on a rental basis and with a modest royalty—the machinery and advice needed for the Vacuum Concrete Process.

VACUUM CONCRETE
INCORPORATED

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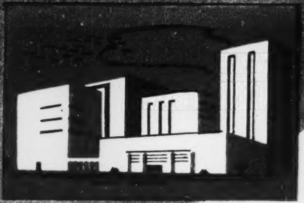
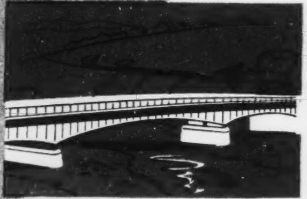
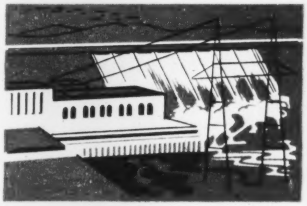
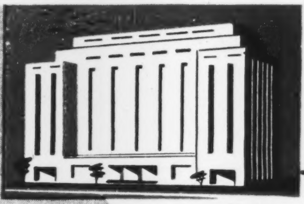
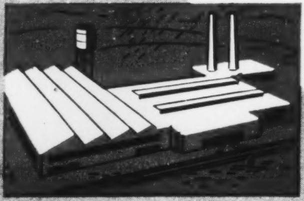
PENNSYLVANIA











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It's The MACOMBER V BAR JOIST

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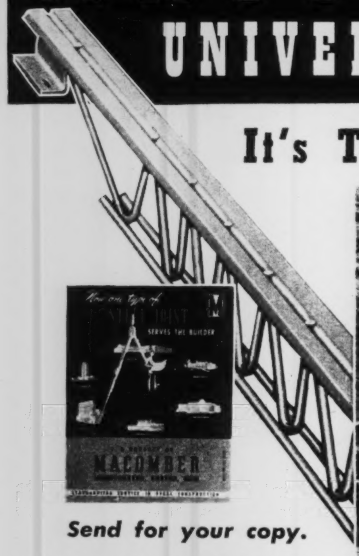

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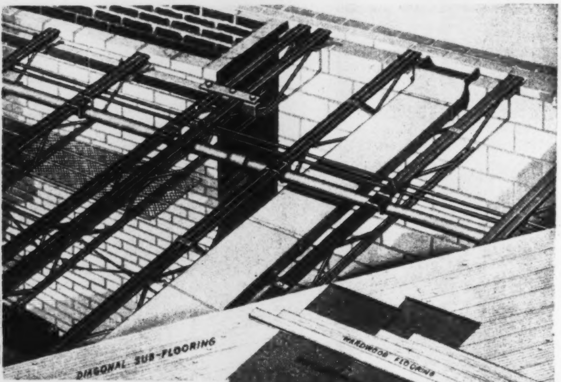
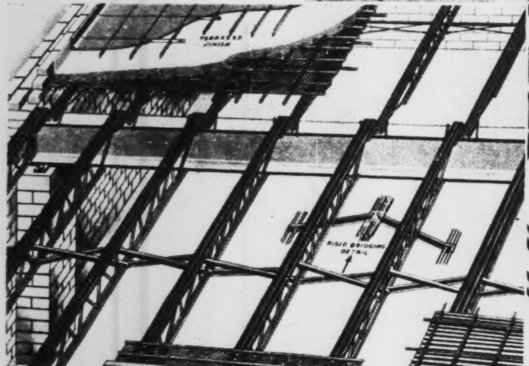


DIAGONAL SUB-FLOORING
HARDWOOD FLOORING



TERRAZZO FINISH
RIGID BRIDGING DETAIL
CONCRETE SLAB
WITH WOOD FINISH
CONCRETE SLAB

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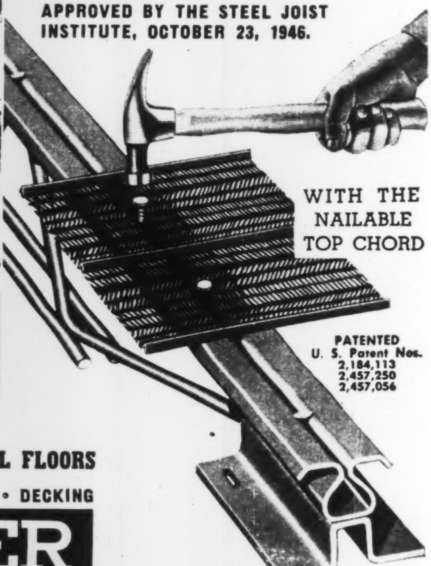

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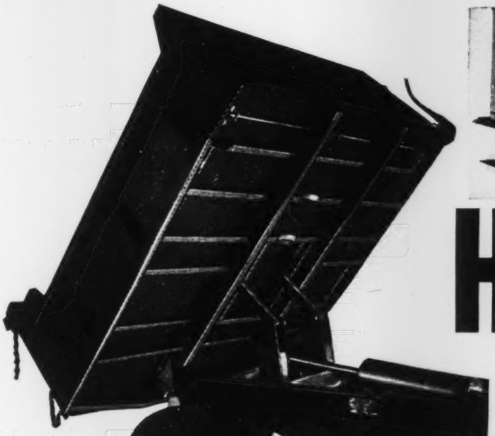
assure less downtime..because

(1) HEIL Bodies use both cross members and long members of the subframe for support, giving you extra strength and longer life

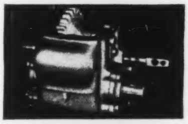
(2) HEIL Hydraulic Hoists are so reliable that you never have to replace a piston due to wear

More days on the job, lower maintenance and repair expense mean *lower hauling costs* with Heil Bodies and Hoists. These money-saving dump units are built to stand up under heavy punishment — to stay on the job and get results. For full information on Heil Bodies and Hoists send in the coupon below, today. BH-141A

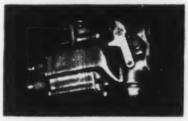


Heil's standard contractors' body has V-section side braces that prevent tailgate spreading.

Heil's heavy-duty rock body for off-the-highway operations. 70° dumping angle gives fast, clean discharge.



There's a sturdy Heil Power Take-off for every make of truck transmission.



Only two wearing parts in a Heil oil-gear pump —and they are reversible and easily replaced.

Heil's platform conversion hoists convert any fixed-bed truck into a time-saving dump unit.

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Factories: Milwaukee — Hillside, N. J.
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Please send me bulletins describing the dependable Bodies and Hoists shown in this advertisement.

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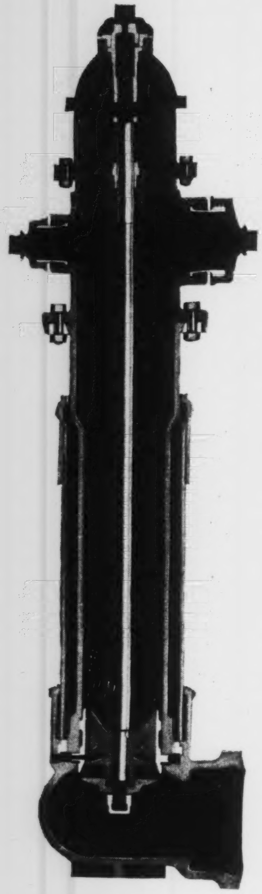
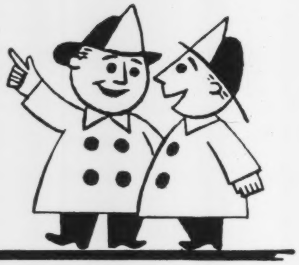


TIME HAS PROVED ITS WORTH



80 years ago the Mathews Hydrant originated two important features—the replaceable barrel and the compression-type main valve. Time and changing conditions have proved the value of these two innovations, and placed increasing dependence upon them. Today, when traffic accidents are the big menace, safety demands a hydrant that can be quickly restored to service, and a main valve that prevents flooding.

Basically sound and simple in design, the Mathews Modernized Hydrant has gone through a process of adapting itself to growing requirements. It has become ever more serviceable, easier to repair, and simpler to replace. The modern, safety-conscious community can choose no better.

R. D. WOOD COMPANY

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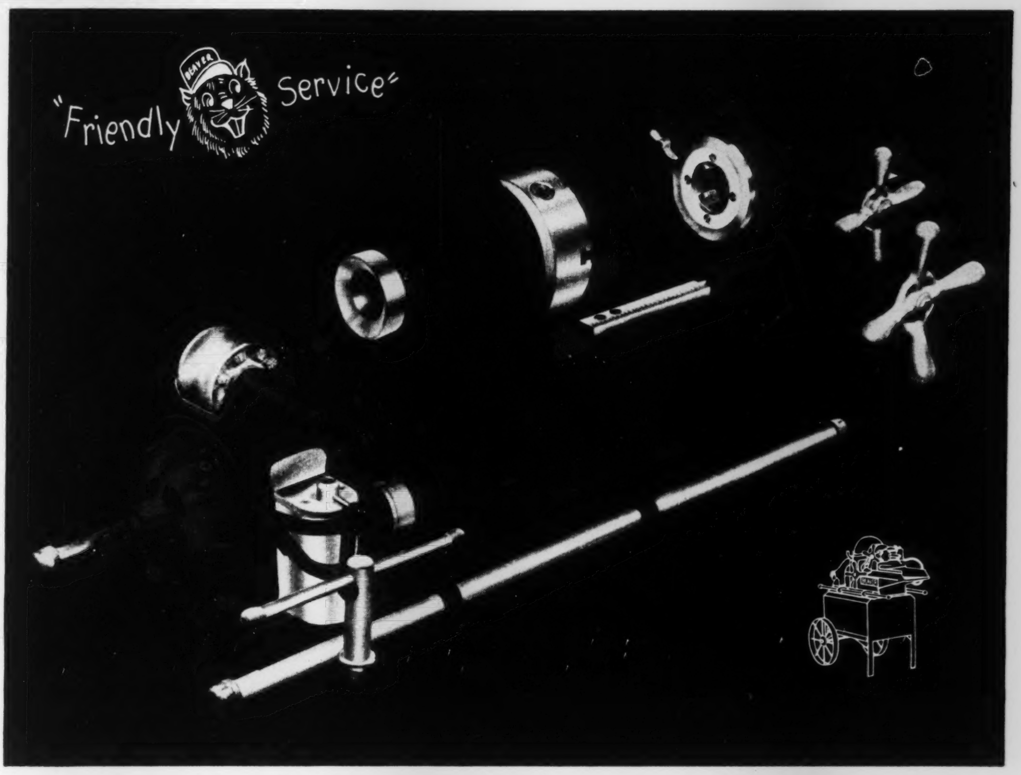
Manufacturers of Mathews Hydrants and "Sand-Spun" Pipe (Centrifugally Cast in Sand Molds)



Two new improvements added to the BEAVER MODEL-A Pipe and Bolt Machine

Many improvements have been made in the Beaver Model-A Pipe & Bolt Machine since it was first introduced 14 years ago. Now, two more improved features are added—both protected by patents pending.

First—an Automatic Switch Lock which makes it impossible to start the machine unless the chuck wrench is in its holder. This protects the workman against injury and the machine against damage.

Second—an Eccentric Spool Pipe Rest (independent from the revolving spindle) which absorbs the "whip" of long lengths of rotating pipe and prevents excessive wear on the spindle bearings. More important still, it eliminates "flat-sided" threads, which leak, caused by spindle rock.

BEAVER
PIPE TOOLS

350-400 DANA AVE. WARREN, OHIO, U. S. A.

MODEL-A FEATURES

Cuts and threads pipe, 1/8 to 2-inch . . . With driveshaft and geared tools the range is increased to 2-1/2 to 12-inch pipe . . . Cuts off bolts 1/4 to 3/4-inch . . . Threads bolts 1/4 to 2-inch . . . 186 different kinds and sizes of dies available from stock . . . Choice of motors, 110, 220, 440 or special voltages . . . Choice of wheel or knife cutoff, both patented . . . Gear driven, with gears running in oil . . . Visual oil level gauge . . . Right-hand operation like a lathe . . . Accessible oil pump for easy cleaning . . . Quick-opening, fully adjustable dieheads . . . Backed by 49 years of experience and a world-wide reputation for high quality, good performance and friendly service to users.

Ingenuity TO MEET ANY FOUNDATION PROBLEM

Foundation engineering is not an exact science to be solved by formula or handbook. No two sites or problems are identical. Some are simple; others are so tough that only top-level experience and resourcefulness succeed in solving them. WESTERN has licked many tough jobs since its start in 1924 . . . jobs where it was necessary to get off the beaten path and utilize or create new techniques. These three recent projects typify WESTERN ingenuity.

SEE OUR CATALOG IN SWEETS FILE

Protection of H-Beam Piles Against Corrosion

Turbine Bldg., General Electric Co., Schenectady, N. Y. WESTERN devised an economical method* of scouring and encasing the upper 10 to 30 ft. of 4,666 H-Beam piles installed at this project, after the piles had been driven. Provision is made in this method to place the concrete in the dry. The 12 in. 53 lb. H-Beam piles were encased in protective concrete blocks 16" x 16"... a minimum of 2 in. protection all around.

DO YOU HAVE A FOUNDATION PROBLEM? WESTERN affords prompt consultation in any part of the country. Write for Catalog A.

*Patented.

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WESTERN FOUNDATION CORPORATION

308 W. Washington St., Chicago 6, Ill. • 2 Park Avenue, New York 16, N. Y.

Concrete Ring Wales in Cofferdam

Union Electric Power Co., Venice, Ill. The 100 ft. dia. cofferdam in the Mississippi River facilitates construction of the Circulating Water Intake. The reinforced concrete wales, used instead of usual cross bracing and "spiders," leave the entire area open for construction. In addition, they afford great strength and economy. It was possible to use a floating hydraulic dredge inside the cofferdam for most of the excavation; the ability to install and remove the construction equipment quickly, simplifies installation of the Drilled-In* Caisson foundations and pouring of the Pump Well Structure.

Driven Core Composite Pile

St. George Ferry Terminal, New York City. This high capacity pile can be driven to depths of more than 50 ft. and will support exceptionally heavy loads. The steel H-Beam core is driven through the concrete filled shell to practical refusal. On this job an 8 in. H-Beam was used inside a 16 in. diameter shell. A test load of 216 tons on a single Driven-Core Composite Pile, with an 8 in. 40 lb. wide-flange beam, showed a total settlement of less than ½ in. and a recovery with load removed, to $^3/_{16}$ in. Design load was 80 tons.

WESTERN FOUNDATION COMPANY
WESTERN CONCRETE PILE CORP
216 TONS LOAD
ON ONE
WESTERN
½ IN.
DESIGN LOAD 80 TONS

BUTTON BOTTOM PILES • COMPOSITE PILES • PEDESTAL PILES • CAISSON PILES • PROJECTILE PILES
COMPRESSED CONCRETE PILES • DRILLED-IN CAISSONS • PRE-DESIGN AND PRE-CONSTRUCTION
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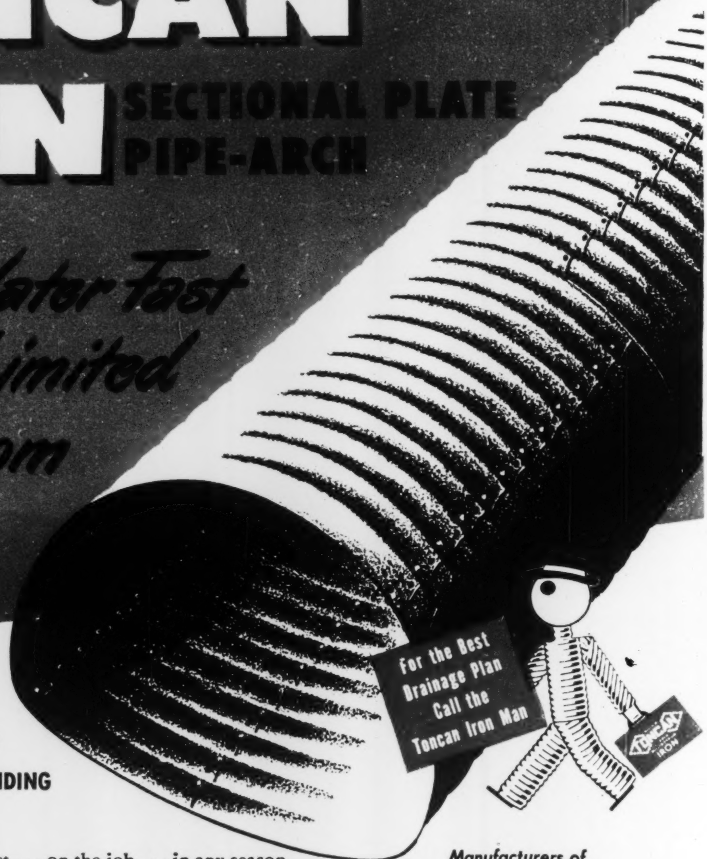
TONCAN IRON SECTIONAL PLATE PIPE-ARCH

Moves Water Fast Through Limited Headroom


For the Best Drainage Plan Call the Toncan Iron Man
TONCAN IRON

LOW, WIDE ARCH
PROVIDES RAPID WATER FLOW
. . . REDUCES LIKELIHOOD OF PONDING

Speeds Construction—Easy to erect . . . on the job . . . in any season . . . with unskilled labor. Shipped "knocked-down"—saves freight. Special bolts and washers, designed for greatest bearing area, develop maximum seam strength.

Carries Heavy Loads—without cracking or crumbling. Strong and flexible—not affected by vibration, impact, settling earth, severe weather changes and other hazards. Two-inch corrugations mean even higher strength . . . wider spans . . . greater economy.

Resists Rust—contains twice as much copper as copper-bearing iron or steel, *plus* molybdenum . . . resists corrosion . . . insures long, trouble-free drainage. Further protected against corrosion by heavy zinc coating, applied after fabrication.

Cuts Costs—Reduces installation costs . . . assures lowest cost per year of service. Available in wide variety of standard sizes for simplicity and economy. Offers 100% salvage value.

Write for full information and useful engineering data

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Toncan Copper Molybdenum Iron is available in:*

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Exide

The tougher the cranking...the greater the need for

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BATTERIES

Give your Diesel cranking to Exide, the battery that's built specifically for the job. Exide Batteries are noted for their ability to discharge at high rates, maintain high cranking speeds and deliver good service day after day . . . in all climates . . . for many extra months.

For top performance, put Exide Batteries on all your automotive equipment . . . on-the-highway, off-the-highway, Diesel or gasoline engine powered. You can always count on Exide Batteries for dependability, long life and low cost maintenance.

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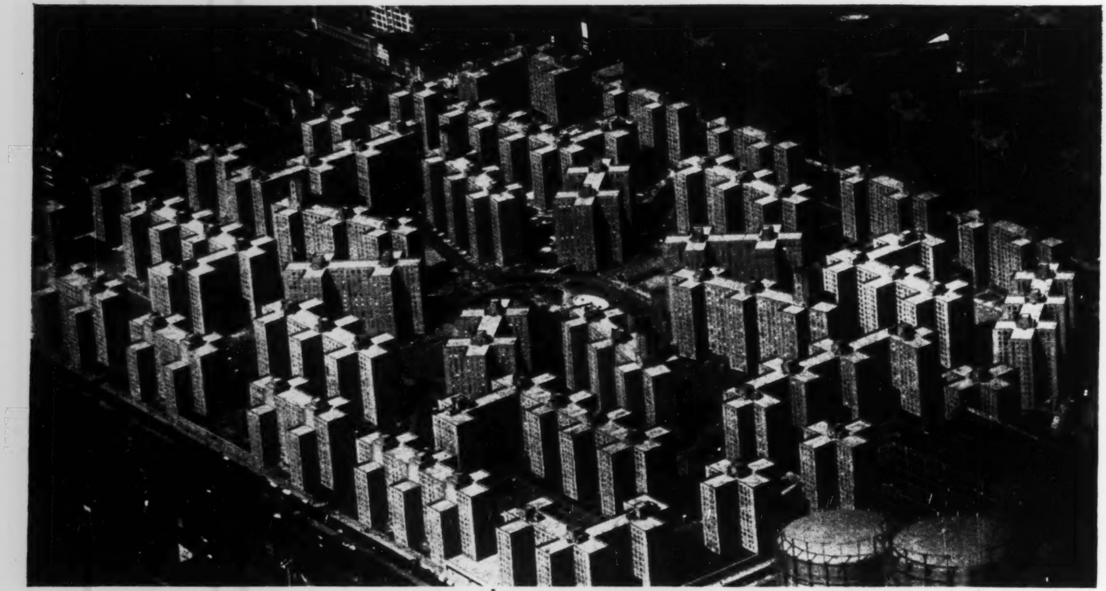
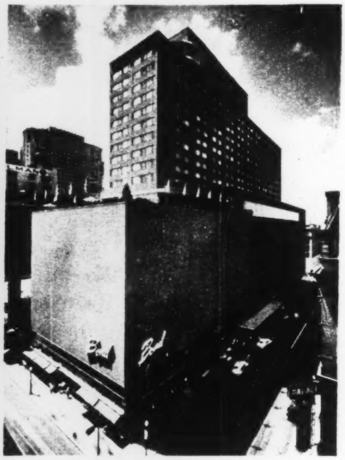
Building with Steel



Stuyvesant Town, New York City—This Metropolitan Life Insurance Company housing project provides pleasant living quarters for some 24,000 people. It consists of thirty-five 12- and 13-story apartment buildings, all fabricated and erected by Bethlehem.

John Hancock Mutual Life Insurance Building, Boston—A twenty-six-story structure, containing dining rooms, lounges, and auditorium. Bethlehem fabricated and erected the 14,700 tons of structural steel.

Civic Opera House, Chicago—Two twenty-three-story wings and a main building of forty-five stories make up this impressive structure. Bethlehem fabricated and erected the 28,000 tons of structural steel.



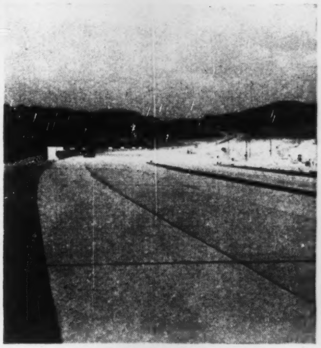
Terrace Plaza Hotel and Store Building, Cincinnati—First seven stories are occupied almost wholly by a department store, while upper stories are a hotel. The steel framework was fabricated and erected by Bethlehem.

across the Nation

Golden Gate Bridge, San Francisco—This majestic structure, built by Bethlehem, is the longest suspension bridge in the world. The main span is 4200 ft, and the two towers are 746 ft high.

Waldorf-Astoria Hotel, New York City—Renowned the world over, the Waldorf has forty-three stories and three sub-basements. Bethlehem fabricated and erected the 25,000 tons of structural steel used in its construction.

Mercantile National Bank Building, Dallas—This thirty-story structure has a steel framework of Bethlehem Structural Shapes.



Pennsylvania Turnpike—This express route from Pittsburgh to Harrisburg is one of many highways for which Bethlehem has erected bridges and furnished steel.

PRUDENTIAL

Prudential Life Insurance Building, Los Angeles—This office building, one of the most attractive on the Pacific Coast, contains 3500 tons of structural steel, fabricated and erected by Bethlehem.

George Washington Bridge, New York City—Crossing the Hudson River at New York City, this is one of many notable bridges built by Bethlehem. The structure has a main span of 3500 ft, and there are two side spans of 610 and 650 ft.

BETHLEHEM STEEL COMPANY
General Offices, Bethlehem, Pa.

BETHLEHEM PACIFIC COAST
STEEL CORPORATION
General Offices: San Francisco

BETHLEHEM
STEEL

ANNOUNCING THE NEW

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CHECK THESE EXCLUSIVE FEATURES . . .

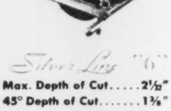
SAFETY-LOCK SWITCH—positive protection against accidental starting.

UNIQUE SHOCK-ABSORBER GEARING harnesses the added power of these great new saws, gives extra life to motor, gears, spindle and blade.

EXTRA WIDE REENFORCED STEEL SAFETY BASE for better balance—easier to handle, far safer to use.

PROTECTED DEPTH AND BEVEL SCALES. In plain sight when you use them—out of the way when you don't. Always accurate.

LONG-SHAFT TRANSVERSE MOTOR-MOUNTING transmits as much as 25% extra power, supports blade on oversize ball bearings from one side of the tool clear to the other.



Silver Line "6"

Max. Depth of Cut.....2 1/32"

45° Depth of Cut.......1⅜"

Silver Line "7"

Max. Depth of Cut.....2½"

45° Depth of Cut.......1⅞"

Silver Line SAWS

with exclusive Long-Shaft Transverse Motor Mounting
for EXTRA POWER and LONGER TOOL LIFE

PLUS...

... the most powerful motor ever used in electric saws.

... the smoothest operating automatic ball bearing blade-guard ever designed. Rubber snubber.

... die-cast aluminum housings, fully reenforced and protected to withstand rough handling.

... steel inserts for bearings and threads to maintain critical parts in permanent alignment.

... finger-tip control for depth and bevel cuts—no wrenches needed.

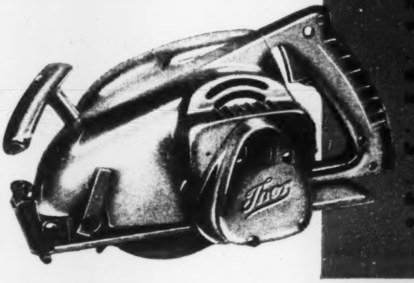
... convenient handles, located for perfect balance and accurate control.

... complete ball bearing construction—with larger bearings than in any saws of this type—all grease sealed or easily accessible for greasing.

... built-in sawdust blower. Blows from the inside—out! Keeps cutting line clean, protects motor from dust.

... giant switches—size for size, the largest ever built into saws. Endless performance.

... steel rip guide, adjustable for any thickness of material being cut.



Ready now—after two years of laboratory and field tests. See the great new Silver Line Saws at your nearby Thor distributor.

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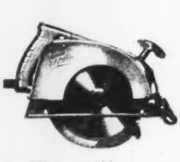
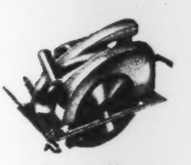
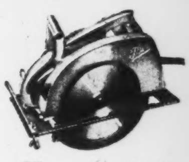
Thor PORTABLE POWER TOOLS



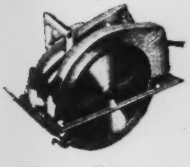
Silver Line "8"
Max. Depth of Cut....2 13/16"
45° Depth of Cut.......2 5/32"



Silver Line "9"
Max. Depth of Cut.....3 5/32"
45° Depth of Cut.......2 3/8"



Silver Line "10"
Max. Depth of Cut.....3 3/8"
45° Depth of Cut.......2 3/8"



Silver Line "12"
Max. Depth of Cut.....4 7/16"
45° Depth of Cut.......3 1/4"

GEARED to the Concrete

The deep, reversed, double-helical ribs of Inland HI-BOND reinforcing bars grip the concrete with an interlocking action that provides unequaled bonding strength.

Engineering tests have proved that straight embedments of HI-BOND have a greater bonding effectiveness than bent-bar anchorages of ordinary deformed bars. And, with ordinary bars, the low bonding strength of the bar has always been the weak link in the structure—the bar would slip before the steel or concrete could be fully loaded. With its high bonding strength, HI-BOND bars make it possible not only to use more of the potential strength of the steel but also to take advantage of the higher compressive strength of present-day concretes. As a result, HI-BOND is leading the way to radical revisions in present building codes.

The present demand for HI-BOND greatly exceeds our ability to supply it. However, to make larger tonnages available to you, we have licensed other steel companies to make this superior bar. Write for booklet.

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38 S. Dearborn St., Chicago, Ill.
Sales Offices: Chicago, Davenport, Detroit, Indianapolis, Kansas City, Milwaukee, New York, St. Louis, St. Paul.

INLAND
HI-BOND
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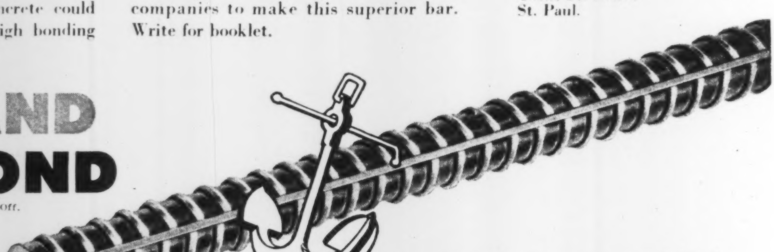
INLAND STEEL



The Reinforcing Bar with the "BUILT-IN" ANCHORAGE!

OTHER PRODUCTS: BARS • STRUCTURALS • PLATES • SHEETS • STRIP • TIN PLATE • FLOOR PLATE • PILING • RAILS • TRACK ACCESSORIES

high output
at low cost

with dependable

Sterling heavy duty motor trucks

The Correale Construction Company and its subsidiary Companies have been a consistant user of Sterling Motor Trucks for the past 15 years. This company has approximately 100 Sterling trucks of various heavy duty models in service on strip mining operations, showing that Sterling's offer the most in operating efficiency, resulting in repeat orders from its many satisfied customers. When you want high output at low operating cost, choose Sterling, the "Famous Name" of heavy duty motor trucks.

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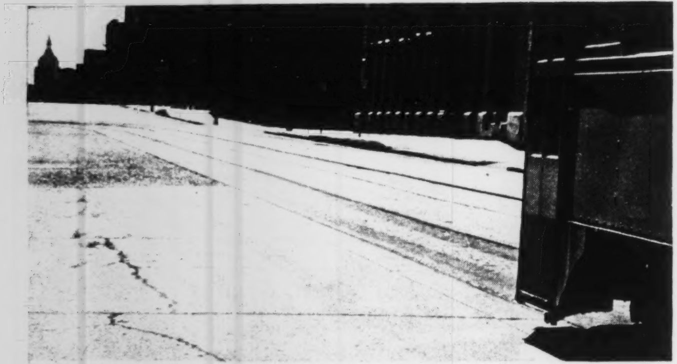
First Ten Years *prove:*

Atlas Duraplastic* Air-Entraining Portland Cement

makes concrete more durable

A Decade of
ATLAS
DURAPLASTIC
AIR-ENTRAINING
PORTLAND
CEMENT



TEN YEARS AGO, in August, 1939, this concrete test paving was laid in Second Avenue North, Minneapolis. The badly scaled section of roadway in the background was made with regular portland cement. The foreground section, *laid at the same time*, was made with Atlas Duraplastic—the first commercial use of the air-entraining portland cement originated and developed by Universal Atlas.

Both sections, subjected to the severity of 10 Minneapolis winters and to heavy applications of de-icing salts, are shown above as they appeared in July, 1949—convincing proof of the characteristic durability of Duraplastic concrete, of its high resistance to freezing-thawing weather and the scaling action of de-icing salts. Longitudinal structural crack shows some ravelling. Note perfect transverse joint.

FROM its first small commercial use in 1939 to the super paving and construction jobs of today, the outstanding durability of concrete made with Atlas Duraplastic has won increasing recognition among engineers and contractors. Proof of its wide acceptance: In 1939, less than 60,000 barrels of Duraplastic were used for paving, then its sole use. In the following ten years, more than 25,000,000 barrels have been applied to an expanding variety of concrete uses.

For Paving Concrete, Duraplastic creates entrained-air cells in the concrete that minimize bleeding and segregation and thus protect it against the scaling action of freezing-thawing weather and de-icing salts (see photo). Less mixing water is required for a given slump. The resultant mix is more plastic, more cohesive, more uniform. It dumps, screeds and finishes easily.

For Structural Concrete, Duraplastic imparts to the mix the extra plasticity that aids proper placement. Water gain and segregation are reduced; surface appearance is improved. Because of these advantages *and* added durability, architects, engineers and contractors today rely on Duraplastic for all types of mass and structural concrete—for foundations, walls, floors, columns and other construction. And they find it readily adaptable to slip-form work, gunite, stucco and other uses.

For Concrete Products, finished units of block, brick, pipe, drain-tile, silo staves, etc., exhibit greater resistance to passage and absorption of water. For machine-made products, manufacturers find Duraplastic permits a damper mix that is more cohesive, holds together better and feeds easily through machines. Plants report savings in fewer culls and throwbacks and less breakage in handling green products.

For construction needs of today and tomorrow, Duraplastic offers *better concrete at no extra cost.* It provides the precise amount of air-entraining agent interground with the cement for satisfactory field performance. It complies with ASTM and Federal specifications, sells at the same price as regular cement and calls for no unusual changes in procedure.

Send for **New Free Booklet,** "A Decade of Atlas Duraplastic Air-Entraining Portland Cement." Write to Universal Atlas Cement Company (United States Steel Corporation Subsidiary), Chrysler Building, New York 17, N. Y.

OFFICES: Albany, Birmingham, Boston, Chicago, Dayton, Kansas City, Minneapolis, New York, Philadelphia, Pittsburgh, St. Louis, Waco.

"Duraplastic" is the registered trade mark of the air-entraining portland cement manufactured by Universal Atlas Cement Company.

CP D-92

ATLAS DURAPLASTIC TRADE MARK REG. U. A. C. CO.

AIR-ENTRAINING PORTLAND CEMENT

MAKES BETTER CONCRETE AT NO EXTRA COST

A UNIVERSAL ATLAS PRODUCT

"THE THEATRE GUILD ON THE AIR"—*Sponsored by U. S. Steel Subsidiaries—Sunday Evenings—NBC Network*

ENGINEERING NEWS-RECORD

1874 1949

MEMO TO THE READER

September 1, 1949

SUBJECT: *The Next Fifty Years*

YOU, THE READER, are a very important person in the world today. You may be a civil engineer or a contractor, a manufacturer or a salesman, a banker or a public official. Whoever you are, if your job relates to construction, the next fifty years poses a challenge to your talents that is unsurpassed in history.

During this half century, that begins in about four months, America is destined to set the pace and provide the leadership for all the rest of the world. Civilization is bursting the seams of its desires. And since civilization moves upward on steps fashioned by construction, it is from those who follow this calling in all its ramifications that great deeds are demanded

These facts faced the editors when, many months ago, they began to think about a suitable way to celebrate the 75th anniversary of this journal. In this three-quarters of a century, *Engineering News-Record* has recorded, and sometimes smoothed, the steps by which America grew from a small nation to a world power. What better way to commemorate this long period of service than with an epitome of current knowledge that would be a springboard for the future.

So this special issue was conceived and planned not just to look backward with pride, but to provide a tool for the job ahead. It seeks:

1. to offer practical solutions to problems that are keys to future progress.
2. to create a deeper understanding of the economic and social implications of construction.
3. to instill a feeling of justifiable pride in all those who serve construction

The fulfillment of these purposes is unfolded in the pages that follow

In the article, "Building A Greater America," the key role that construction plays in shaping American civilization is outlined. In an economic sense, through the jobs it provides and the business that it generates, construction is a vital cog in our industrial system. Socially, through water supply, sanitation, shelter, transportation and the like, it is construction that has made our high living standards possible.

If these standards are to continue to rise, new knowledge is needed to solve the problems that this next half century will soon introduce. So we asked specialists – more than a hundred authorities in all: "What are the outstanding problems whose solution would have the most influence on future progress?" From the replies, a dozen subjects were selected, and the best possible authorities invited to develop them. The result is a symposium of proved and provocative ideas presented under the general title of Molding the Future. Here are, we believe, some useful tools for tomorrow.

Useful, too, can be the heritage of the past. Many histories of civil engineering have been written, but none has attempted to single out those particular events that were truly significant to the march of progress, and thus inspiring and useful for the future. Again seeking the counsel of numerous authorities, we sifted from the many memorable happenings those which had proved their significance. The result is a new kind of history. You will find it presented as The Almanac of Significant Events in Building a Greater America.

Finally, and with the same objective of drawing on the past for guidance in the future, we have considered it appropriate to include the biography of Engineering News-Record. Three-quarters of a century is a venerable age, and during that period, this journal has been a constant companion of the men who made civil engineering and construction history. We find inspiration in the events it recorded, lessons in the reports of successes and failures of great engineers whose names have graced its pages. All this is useful for the future in the shaping of which we hope to have a continuing part. We think you may find pleasure and profit in reading "Making History – Engineering News-Record's Role in Building A Greater America."

You who practice "the art of directing the great sources of power in nature to the use and convenience of man" have come a long way in 75 years. The fruits of your deeds are all about you. A half century of opportunity opens before you. This issue is dedicated to the challenge thus offered. No goal could be more worthy than to build a greater America equal to the responsibilities that world leadership imposes.

THE EDITORS

GREAT CIVIL ENGINEERING WORKS like Shasta Dam mean higher living standards—in this case more food and power, better flood protection.

Building A Greater America

AMERICA will be a great place—if they ever finish it. This quip, originally a vaudeville laugh line, is now a part of the American language. Frequently uttered in annoyance, it nevertheless mirrors a definite pride. America never will be finished. As the orators say, this is a growing country. We like it that way. And the food for the growth is the combined ingenuity, courage and ceaseless work of the civil engineer, the architect and the construction man.

Of all the major powers in the world today, only America was actually built. Countries in Europe just grew, new civilizations and new cultures piled atop the old. Only America was started from scratch.

America developed a new civilization because its citizens never accepted its living standards as good enough. There was always something better, that could be attained by effort, by giving each man freedom to exert that effort and, most of all, by seeking to reduce the muscular effort by the use of machines.

Today, on the threshold of the last half of the 20th century, America stands in a position of world leadership. This happens not because Americans were chosen by destiny to play that role, but simply because our way of life made us powerful at a vital period in world history.

This asset must still be relied upon, indeed must be developed more vigorously, if living standards not only for ourselves, but for much of the rest of the world, are to continue to rise—if America is to fulfill its opportunity for world leadership.

Thus, even though they may never finish it, the designers and constructors are more than ever dedicated to keeping it growing, in short to "Building a Greater America."

Let a stranger come to this land and ascend the low hills of New Jersey of a summer evening. The sun's waning rays on the spires of Manhattan highlight a breath-taking tribute to the American builder. Still, the buildings of New York are merely one example, albeit an appealing one to the public, of construction's contribution to American civilization. There are many others, some far more impressive and significant: water supply, sewage treatment, tunnels, dams, roads, waterways, harbor facilities, bridges, in every corner of the land. There are the homes, the hospitals, the factories, the churches and the schools.

These things of timber, of concrete and of steel are the handprint of construction. But the engineer's and construction man's America is more than just these visible things. Thus, flood control is not just dams and levees, but a safeguard for our homes, our farms and our factories. Water purification and sanitation improve health and extend the useful life of millions of persons. Slum clearance removes the breeding places of crime, gives enlarged opportunity to cultural and spiritual development. Reclamation extends our geographical frontiers. And our great highway net breaks down sectional prejudices, ends the isolation of the farm and brings good schools within the reach of every child. These things that make possible a richer and more rewarding life, even more than the mere physical structures that are built, are the real assets that construction creates.

Better living, great industries

There are other assets, too. In 1948, money spent on all construction amounted to nearly $17.5 billion, about 8 percent of the total national income. It has been as high as 12 percent. Yet only a small amount of that money is spent on raw materials. The bulk of it goes into wages—in the factory and in the field. And the construction workers who fashion the materials into structures are among the highest paid hourly employees anywhere. So one part of the construction man's America is better food, clothing and the things to live by than a man gets any place else in the world.

Let the stranger to this land stand on the sooty hills above the Monongahela or Alleghany rivers and gaze down on Pittsburgh's fabled "Golden Triangle," and the slender, red-rimmed smokestacks marching up the valley behind it. Here is the steel center of the world, with a capacity twice as great as that of any other nation. Capacity is never created except by demand—and construction demands millions of tons of steel a year. So another part of the construction man's America is the greatest steel industry the world has ever known.

Let the stranger journey west and

"IF THEY EVER FINISH IT"—Building and rebuilding, the process of creating a greater America goes on. Here a swath is cut through New York's skyscrapers for the approach to the Brooklyn-Battery Tunnel, to close one of the oldest and most serious transportation gaps in the country.

north, to Detroit. Here and nearby are produced the world's greatest number and variety of automobiles. The automobile manufacturing industry has a gross output of about $5 billion a year; its satellites—service stations, accessory dealers, the great petroleum industry itself—add billions more. The automobile industry and its satellites employ about 7 percent of all the workers in the country. It uses about one sixth of the steel exclusive of what the petroleum industry consumes. And the automobile industry, as its spokesmen will tell you, grew only with the construction of roads. It continues to grow because more roads are continually being built. The automobile and the petroleum industry are also a part of the civil engineer's and the construction man's contribution.

Our stranger should take an airplane to the farthest coast—here are other marvels of the construction art.

Los Angeles is the country's fourth largest city, a wonderful place of green and growing things. Only 50 years ago, the City of the Angels was a place of parched hills and scrubby growth.

Water brought by engineers and construction men from hundreds of miles away has changed all that. This whole lovely belt of southern California, from Los Angeles to the Mexican border, is a great, an especially cherished part of the construction man's America. Here he has made possible the fastest growing industrial section of the nation.

Back several hundred miles from the Pacific Coast are Hoover Dam, Parker Dam, the great aqueducts from north and east taking the water to Los Angeles and southern California—these are the keys. Lake Mead, backed up behind Hoover Dam, is the largest man-made lake in the world.

But this lake and hundreds like it of lesser size, made or in the making, are enhancing living standards in other ways. Their waters cascading through electric turbines are generating the power for new industries. Used once or twice or four times for this purpose, the waters are directed into canals that feed arid lands and cause them to bloom.

Food from new frontiers

In terms of what can be done, the job really has just started. The West has 21 million acres under irrigation, but there are 17 million more to which water can be brought.

Still, the job already done is magnificent. Prior to the passage of the national reclamation law in 1902, 9 million acres had been irrigated and since that time 5 million acres have been added. In addition, water from the dams spilling through turbines generate 2.5 million kilowatts of electricity. The projects serve 5 million persons—one-fourth of the population in the 17 western states.

To focus on a smaller area for a moment, the construction man's contribution to Arizona's economy is simply stated: 90 percent of the cultivated land in that state depends upon irrigation. Or take Imperial Dam on the Colorado River near the Mexican border, from which water is furnished for agriculture into Arizona and California. From the dam, a great ditch, the All-American Canal, carries water to 1,400 square miles.

This is the Imperial Valley, one of the lushest pieces of agricultural real estate in the world. Like most of the rest of the desert it gets only about three inches or so of rainfall a year. But when the Colorado's waters were brought in, Imperial Valley was transmuted.

Californians tell a story about a priest being shown through the Imperial Valley by a parishioner. Looking out over the riotously-growing crops, the priest sighed contentedly as he said:

"What a wonderful spot God and man have created here."

His companion smiled understandingly. "Yes, Father, but you should have seen it before man worked it over."

So part of the construction man's America is more food—food out of seasons—and agricultural wealth where before there was not even a living.

Freedom from disease

But the America of the civil engineer and the construction man is more than the things that delight the eye and awe the mind. Here you will find freedom from diseases that in other lands lurk in germ-laden waters, that strike from the stings of insects or originate in the parasites of rodents.

When grandpa was a boy in America he could expect at least two of his neighbors to contract typhoid fever every year, and someone he knew to die from it. In 1908, the death toll exceeded 35,000. Today, an abundance of drinking water purified by the sanitary engineer makes it virtually impossible to contract typhoid fever. Scientific sewage treatment helps cleanse the waters, and eliminates breeding places for disease-carrying insects.

The scourge of malaria no longer threatens vast areas of the country, thanks to the construction man's drainage projects. How many deaths have resulted from bubonic plague will probably never be known. But ratproof construction and general cleanliness of surroundings make it a disease unknown to millions of Americans.

Triumphant in their own country, American engineers are applying their disease-prevention experience all over the world. In South America, they are cooperating with local health services to provide safe water supplies and sanitary sewage disposal. More recently, in cooperation with the Italian government, American engineers are participating in a vast field experiment to stamp out the malaria mosquito from Sardinia, second largest island in the Mediterranean. Methods used there—spraying with DDT and clearing and draining with bulldozers—are based on techniques used successfully in Brazil and Egypt by American engineers.

Supplier of transportation

But to return to things more readily visible, let the stranger to this land behold the most marvelous and intricate transportation system the world has ever known. Let him ponder on the history of its development—and pay tribute to the construction man and engineer.

From a toe-hold on the forbidding New England shore the settlement of colonial America first seeped south along the coast and then expanded along the waterways that the settlers

Builder and Customer of Industry . .

STEEL from sprawling mills, the product of the constructor, emerges in millions of tons for the use of other constructors and for such products as . . .

. . . **AUTOS**, whose very existence is predicated upon the great highway network that the civil engineer has conceived and built, creating also employment for millions, a benefit destined to be repeated in . . .

. . . **AVIATION**, whose planes owe their safety and efficiency to the wind tunnel —their ability to operate to the airfields that the civil engineer and the construction man designs and builds.

found. But the all-important links between the natural waterways were the canals, many equipped with locks. It took engineers to plan the canals (a surveyor named George Washington helped on the Chesapeake & Ohio), to design the locks. It required construction men to build them.

The canal age was reaching its flower when along came the railroad. Like the settlers, the railroads were confined to the valleys of waterways. The first trains did not go over the mountains, indeed they did not cross the rivers. The tracks stopped at the great rivers and the passengers or the cars crossed on boats.

Then the engineers and construction men took hold in earnest. One of the first significant achievements in smoothing the paths of travel was construction of the Hoosac tunnel under the Berkshire mountains in Massachusetts. It was started in 1851. Twenty-three years, and $20 million later it was finished, a 4¾ mile bore which for years was the longest tunnel in the world.

Older techniques could not meet the challenge of this tunnel. America's construction men brought something new to tunnel construction at the Hoosac: the first practical use of power drills and dynamite.

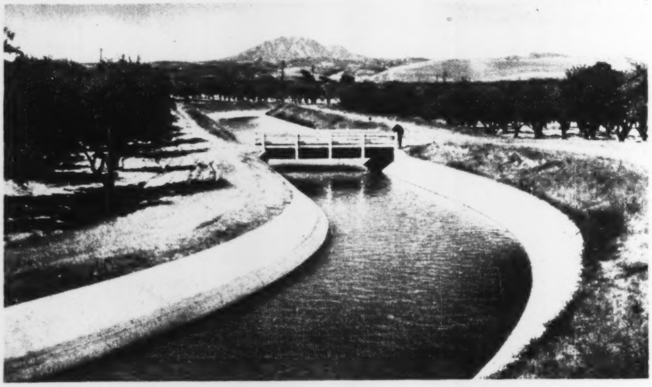
Tunnels put the railroads through mountains; and also under rivers that could not be spanned by bridges. The Hudson tubes from New Jersey to New York constructed shortly after the turn of the century, brought a second railroad into the heart of the nation's greatest city. On this job the construction man made early use of one of his greatest inventions—the compressed air shield that kept the water out while the tunnel was pushed ahead through the river bottom muck.

More important, perhaps, than the tunnels were the bridges. Here the engineers and construction men eagerly seized upon new materials, newly discovered engineering principles. Wrought iron was the commonest construction material before 1874. Although 20 years after Bessemer introduced his blast furnace, steelmaking still was in its infancy. Yet, James B. Eads tried steel—chromium alloy steel—for the tubular arch ribs of a new bridge across the Mississippi at St. Louis. Three years later, William Sooy Smith built an entire bridge across the Missouri at Glasgow, Mo., of a new material—low-carbon structural steel.

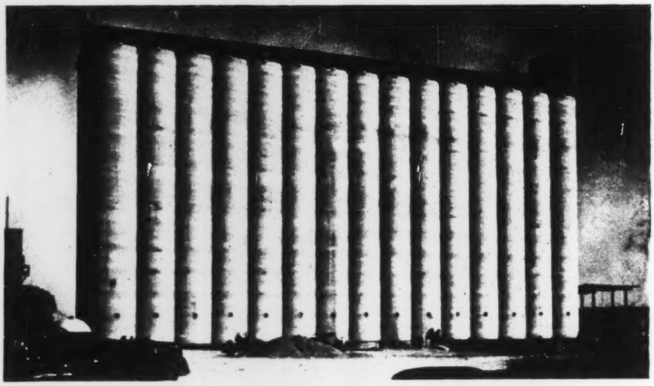
They set the pace; as fast as new materials have become available, engineers and construction men have put them to use (now aluminum bridges are being talked of and built). Eads and Sooy Smith rank no higher than John and Washington Roebling, who pioneered the suspension bridge, stringing cables, first across the Niagara gorge, then for the famous Brooklyn Bridge. The same stringing method is still used, though more mechanized, and the company that John Roebling founded spun the cables for the George Washington and Golden Gate Bridges, the country's largest suspension spans.

Overhead, a bridge, silhouetting its trusses, girders and cables against the sky, is the trademark of one great class of engineers and construction men. But down below, along the river's shore, or at its murky bottom, are the products of still another. Pneumatic caissons are effective to a depth of about 100 ft. And that was one of the things that stopped the paths of travel: the need to go deeper for bridge foundations. One advance came in 1888, when open caissons were used for the piers of a railroad bridge across the Hudson River at Poughkeepsie, N. Y. The river bottom was dredged, then the caissons sunk 134 ft. Using the same technique, foundations have continuously gone deeper—242 ft. for one of the main piers of the San

Factor in Food Production . . .



IRRIGATION CANALS, such as this one in California, make the desert bloom and bring forth fruit, often supply towns and industries with water.



GRAIN ELEVATORS, reservoirs for the golden streams from countless farms, supply the cereal processors with their raw materials. This one at Redfield, Ia., holds a million bushels.

. . . Supplier of Shelter

HOUSING, basic necessity next to food, is also a conditioner of character, particularly when large community groups of sun-oriented buildings replace a city's slums.

FACTORIES are shelter too—for the machines and men who produce our clothes, food and furniture or, as above at Oak Ridge, atomic materials for our protection.

Francisco-Oakland Bridge, for example.

Thus have the jobs been done to close the transportation gaps. Today, much of the construction man's transportation work involves highways. Even that is founded on a long history of trying to build a better country. The length of surfaced roads in 1830, at the time of the coming of the railroads, was about 27,000 miles, built by manual labor aided by ox-drawn plows, horse-drawn scoops for moving earth, road drags or scrapers, wheelbarrows and other agricultural tools. Both of the major types of surfacing used then and in the remainder of the 19th century—gravel and macadam—performed satisfactorily for the horse-drawn traffic of the era.

But automobile traffic about 1904 presented a challenge to highway builders. The wheels of these heavier, higher-speed vehicles scoured the dust binder from the surfacing, which then disintegrated rapidly. Highway engineers solved this problem by substituting tar and asphalt for the weaker mineral binders, first as dust palliatives, then as protective surface coatings and finally as internal binders.

The first portland-cement concrete pavement had been laid in Bellefontaine, Ohio, in 1893. In 1909, there were not more than 5 miles of that type in rural construction. By 1924, the length of concrete pavements had been increased to 31,150 miles, brick to 4,320 miles and bituminous concrete or sheet asphalt to 9,700 miles.

During this period, also, powered equipment came into use. Power shovels speeded up excavation; mechanical mixers took over concrete making from hand labor; and bituminous distributors were introduced.

Roads to everywhere

The highway construction man's golden age—and golden opportunity—began with passage of the Federal Highway Act in 1921. Before that, Congress had twice authorized federal assistance for roads over which mail was carried, but this was different. The 1921 act was to facilitate construction of roads for general commerce (and pleasure), and it required the states to designate a system of interconnected roads and to develop it according to uniform and high standards.

Since then, something around $15 billion has been spent on highways alone, including construction and maintenance. Billions more have been spent on streets and associated developments. It has been the most productive construction investment ever made.

Look at a chart of automotive production, and put it beside a chart of highway construction. There is the graphic answer to what the construction man has done for American travel —and for one American industry.

Make still another comparison — with the truck ton-miles chalked up. Every night, giant trucks snort out from New York, Chicago, Philadelphia, Atlanta, San Francisco, every one of the metropolitan centers. They too are the spawn of the roadbuilders, behemoths of an industry whose muscles and tendons, ligaments and skeleton are roads of asphalt and concrete, bridges of concrete and steel, tunnels of cast iron and other materials.

From their wellspring, the designers and the builders of transport facilities have extracted other wonders, wrought other miracles—the modern waterways, the ultra-modern airways. Under their guiding hands great river courses have been transformed by dams into a series of pools through which boats, pulling long tows of barges of commerce, proceed unhindered by currents; and into which they climb or are lowered by locks, each as long as a dozen of those of the type that graced the early canal age of the country.

than $2.5 billions are charted for schools in the next few years. And to what the cities, the states and private agencies can do in the hospital field has recently been added the powerful force of federal funds—more than a billion dollars for veterans, in the hundred millions for the ordinary citizen. These facilities are much more than just amenities in the construction man's America! They are a part of the fabric, and the satisfaction in designing and building them is second only to that which comes from manning them after they are finished.

Consider also that until recently most of the factories in which America's workmen were supposed to produce the goods to remake a world were as noisome and unwholesome as many a tenement district. Now the health and safety of the industrial worker are considered basic, and new factories respond to these needs.

Today also the construction man and engineer are faced with other industrial-born problems. As industry expands its use of strange materials, temperature and humidity can mean the difference between a saleable product and junk. Interior layout can mean the difference between profit and loss, and the difference between good labor relations and a strike.

Here is a textile mill in Virginia: a one-story, windowless structure of 130,000 sq. ft.; several air-conditioning and ventilating and humidification systems meet different processing requirements; good lighting; mechanized material handling; color used to ease strain on eyes and nerves; music through a public address system; walls, floors and ceiling treated to deaden sound, make cleaning and maintenance easy.

Here is an aluminum rolling mill in Iowa: a one-story building covering 52 acres; 3.3 miles of 9½ in. thick concrete wall ranging from 4 to 11 ft. high; 454,000 sq. ft. of sash with heat absorbing glass; 295,000 sq. ft. of cellular, insulated aluminum wall panels above and between the sash; 44 acres of aluminum roof deck; 7,000 incandescent, fluorescent and mercury lighting fixtures; bay areas 33 to 50 ft. high; truss spans 60 to 100 ft.

Here is a concrete hangar in Maine: clear span of 340 ft. with clear height at center of 90 ft. Over 40 percent of its artificial heat is radiated from the floor in which steam pipes are embedded.

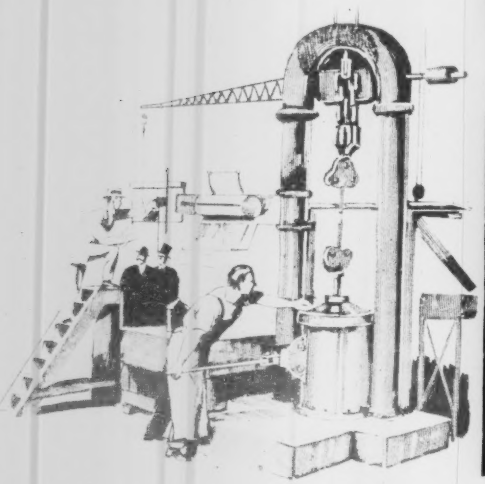
The new factories are one of the newer contributions of the construction man and the engineer. The gimmicks and the gadgets and doodads spewing from American factories—these, too, are becoming part of the construction man's America.

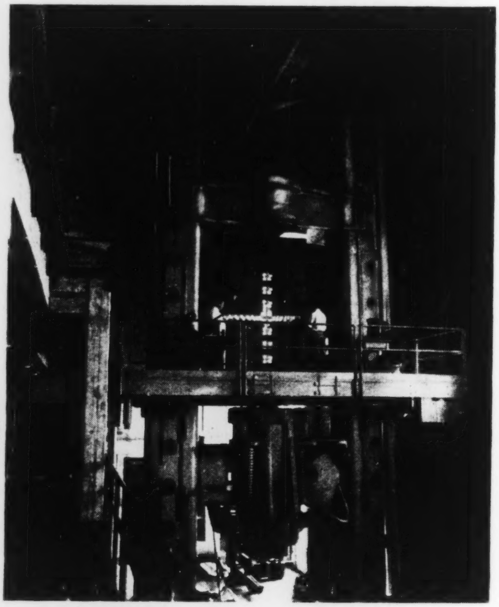
The stranger to these shores would see all these things—skyscrapers, acres of homes, great bridges, huge dams, intricate road systems, sprawling efficient factories. He would marvel at them for a while, but soon accept them as commonplace, as Americans do, even sometimes the engineers and construction men who conceived and built them. This would be a mistake. It is important to know and appreciate why these things can exist in America—and nowhere else in the world.

Machinery makes it possible

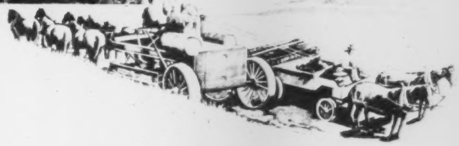
The freedom of the individual, our free enterprise system of business, forms the real foundation. And out of its essentially new way of life has come the urge to build faster, above all to use machinery to lighten man's dependence on his muscles. The engineer and the construction man have been pioneers and leaders in this mechanizing process. Each achievement, greater than the one before, has been a monument to mechanized construction.

The Hoosac railroad tunnel was completed in 1875 for a length of nearly 5 miles with power drills and dynamite. But a few years ago New York City finished an 85 mile water tunnel. Air drills, a dozen on a single carriage, had replaced steam; dynamite was set off by electric blasting caps; mucking machines cleared away





MATERIALS TESTING for the Brooklyn Bridge in 1874 required small specimens, manual operation. In contrast, towering modern machines (as at the University of California) will test columns 33 ft. long in compression or, as shown, test a 6-ft. wide steel plate in tension.



TODAY'S ELEVATING GRADER, hauled by a crawler tractor and discharging into huge rubber-tired wagons, is a streamlined giant compared to its famous horse-drawn predecessor that helped build the early railroads and highways.

Up and down the Ohio, the Tennessee, the Mississippi and the Missouri, steel, coal, lumber and grain move between buyer and seller as the process of building a greater America goes on. They move in channels protected by levees that guard the farms, the factories and the homes along the banks that otherwise would be periodically overtopped by floods. As a tamer of rivers the construction man has also made a contribution to civilization.

The construction man's America is also the land of air travel—in passenger miles, in ton-miles, in speed and in size of conveyance the peer of all the world. Except for airports, the airplane would be merely a useless mechanized monstrosity. Given the runways that the construction man provides (and the vast drainage systems and passenger and freight buildings that are the products of the engineer and the architect) the airplane translates travel to new dimensions of swiftness, serves business and supports industry. In a very real sense, in this age of rockets and atomic bombs, it provides the security that a great nation requires to exist and flourish. Even the wind tunnels, in which the new designs of ever-more-efficient planes are incubated, come from the experienced hands of civil engineers and construction men. Our stranger who flew from coast to coast was beholden to them through every mile.

Transportation in its many forms is one of the outstanding symbols of a growing, developing America. Better shelter is another. Let a newcomer to this land look at America as a place to live and to work: its buildings rising to the sky, sprawling over acres; its "garden houses" with plenty of light and air for all. These, too, are the construction man's America. They, too, are a vital part of his contribution to civilized living, for the crowded, ill-lighted, fetid shanty-towns and tenements that they replace are an invitation to disease and social ills that a nation dedicated to better living cannot tolerate.

Better shelter for everyone

So, as one solution, Americans are building complete satellite towns. At Forest Park, 27 miles south of Chicago, 2,400 acres are being worked over into a completely new city for 30,000 people. Last year, 250 duplex rental units were constructed. This year plans call for erection of 2,500 more. Then will come 4,000 houses for sale. The architect, engineer and construction man have teamed up at Forest Park to demonstrate good building for better living; a planned street system, water-softening plant, shopping, amusement, educational and recreational facilities.

In New York City—as ill-famed for its slums, as noted for its mansions and penthouses—engineers and construction men are bulldozing the heart out of tenement districts, and replacing the blight with modern, airy apartments.

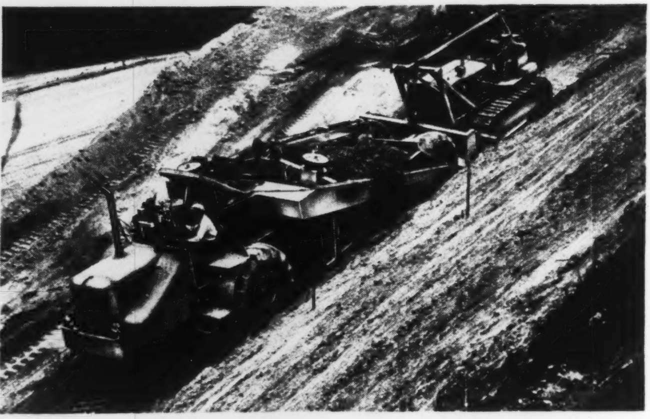
For Stuyvesant Town, 75 acres of run-down New York buildings were razed. On the site were built 35 apartment buildings using only one-quarter of the space. Here live 8,755 families in buildings 12- and 13-stories high. And nearby is Peter Cooper Village, eventually to have 26 15-story buildings, and room for 2,495 families.

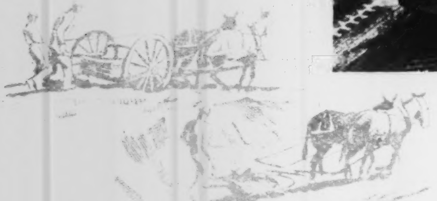
There are hundreds of similar projects, scattered from New York to Los Angeles' Parklabrea, and from Forest Park to the 3,000-home development going up near Tucson, Ariz. Some are paid for by private money, some by public, but all are mass-production housing. If it is scorned by the esthete, it nevertheless provides palatial living compared to any other place in the world, and it costs little enough that the tenants have money left for bus fare to an art museum.

This but demonstrates the effect of buildings on the smallest details of our standards of living. Houses are homes; they mold the character of American youth. Churches and schools guide him into a life useful to himself, to the nation and to society. Theaters and hospitals are servants of his mind and body. Factories and office buildings are the tools of his production; they offer him a livelihood. All are due to the civil engineer-architect-construction-man team.

Take for example the schools and the hospitals that dot this land. Already totaling many thousands, so vital are they to our principles of culture and of humanity, that the supply never equals the demand. More

MECHANIZED EARTHMOVING has made the heroic deeds of the muleskinners with their slips, wheel-scrapers and colorful language, look puny. Output has been increased several hundredfold.





SEVENTY-FIVE YEARS has advanced bridge building from Roebling's handsome 1,057-ft. span at Cincinnati to spans four times that length and to such great projects as the tandem suspension structure across San Francisco Bay.

The really big ones require units that move 20, 30 yd. at a clip.

Similar savings followed improvements to the power shovel which, on rails and powered by steam, had built America's railroads and dug its canals. Internal combustion engines, crawler treads, air and hydraulic controls and large and small dippers of various types give the modern machine a versatility and capacity undreamed of in the early days.

The thousands of miles of hard surfaced roads that pulled the nation out of the mud were not laid by merely putting more men with picks and shovels to work. The power shovel, the truck, the scraper, the tractor, the bulldozer and moving pavers are what did the trick. Even hand-finishing operations on concrete have given way to machines. Spreaders and finishers make asphalt road building an entirely push-button operation.

In 1940, on the Pennsylvania Turnpike, 140 miles of 9 in. thick concrete pavement was placed between April and September. No other age, no other country can make such a statement. This, too, is why the America is a nation of high living standards and the envy of the world.

Then there are those transportation system gaps that were filled by bridges so that 40 million vehicles could be put at the beck and call of 150 million people. The contrasting results of early and present bridge building are nowhere more evident than in the spinning of suspension bridge cables. Roebling spun the two 15-in. cables of his Brooklyn Bridge in 21 months. The Manhattan Bridge cables some 25 years later, containing nearly twice as much wire, were completed in four months. Mechanizing the process with electric motors, the builders of the George Washington Bridge at New York in the early thirties put in 500 miles of wire a day as against 10 miles daily on the Brooklyn Bridge.

Had the ultimate been reached? Not at all. Within five years the Golden Gate cables were placed 6 times faster—by ingenious multiple spinning wheels 24 wires were spun at a time instead of the usual four.

Still other engineers and construction men turned their knowledge and mechanical ingenuity to the foundations of the bridges. For, to meet the needs of our dynamic civilization bridges had to be built where the transportation gaps were, regardless of construction difficulties.

Take the Potomac River bridge at

the debris; electric hoists removed it. Forced ventilation made the tunnel safer, cut down lost time. Centrifugal pumps kept the water out, and plunger pumps placed the concrete lining.

Just after the turn of the century Roosevelt Dam, 280 ft. high and containing 342,000 cu. yd. of masonry, was completed in 5 years. Supplies were brought in by mule over mountain trails. What machinery there was was powered by steam. It was a great engineering and construction feat. Yet hardly more than two decades later, concrete monoliths, ten times, even thirty times larger were completed in less time. Hover Dam, 726 ft. high, contains 3,250,000 cu. yd. of concrete. Shasta Dam has a volume of 5,400,000 cu. yd., and Grand Coulee, a mile long and 550 ft. high, is a 10,000,000-cu. yd. mass.

Only mechanization could make possible such long steps forward. Rail lines and highways were built to the dam sites. Instead of mules, trucks holding a-much as 25 cu. yd. brought in the materials which 4- and 6-yd. power shovels had loaded. At Shasta a belt conveyor nearly 10 miles long—none yet is longer—moved concrete aggregates to the dam. On the down hill sections the conveyor generated part of the power to pull itself up the next hill. Boot-strap lifting has seldom come closer.

For the great quantities of concrete, huge electric mixers were required. Mechanized scientific weighing of the concrete ingredients was a part of the job. At Hoover, and even more spectacularly at Shasta, the 8-cu. yd. buckets of concrete were swung into the dam over long-span cableways; at Coulee, moving cranes, set on the dam itself lifted the buckets into place from rail cars that moved back and forth to the mixers.

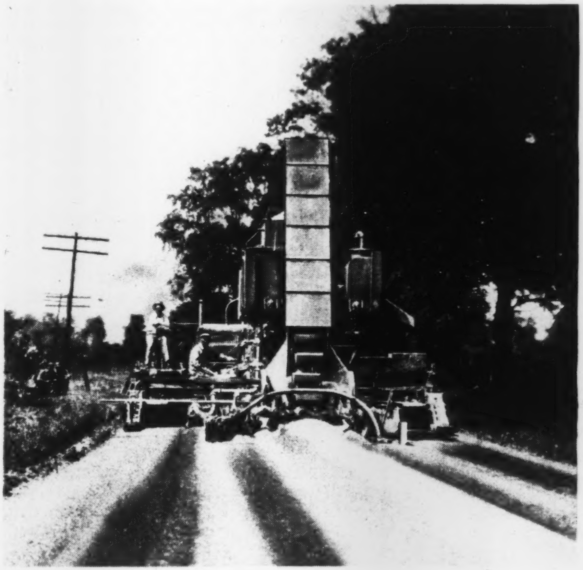
Such masses of concrete generate damaging heat while hardening. To dissipate the heat at Hoover, pipes were buried in the concrete, 150 miles of them, and cold water pumped through. Recently great ice machines have been set up at dams to make ice flakes that are mixed with the concrete for the same cooling purpose.

It is through such spectacular and mechanized handling of its construction problems that America has been built.

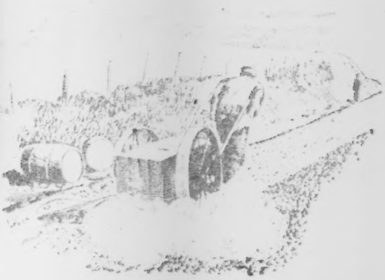
Or take an earth, instead of a concrete, dam. The levees that confine flood-tending rivers are earth dams. So is Ft. Peck whose 100 million cu. yd. make it the largest man-made structure in the world. The great Cheops pyramid of Egypt is only one one-tenth as big. Ft. Peck Dam is 4 miles long. It was built by dredges that deposited as much as 43,000 cu.yd. a day. At Anderson Ranch Dam, another earth structure about a tenth as big but twice as high, the material was moved by belt conveyor and truck, and compacted by rolling. Only machines make such work thinkable.

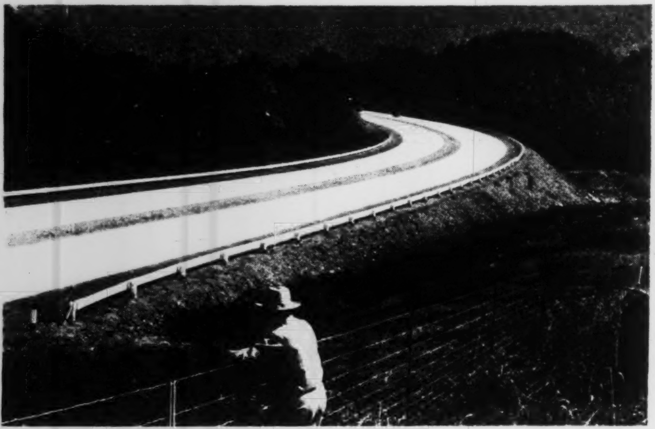
How the construction man has been able to keep pace with the demands for speed and economy is strikingly apparent in the way he makes these earthfills. In the early eighties, when the Southern Pacific was building its line in the Sacramento Valley, where Shasta Dam now stands, fills were made by dumping the material over the top of the embankment and letting it roll freely to the bottom of the slope. Fills so made had the most perverse habits. They continued to settle for the next ten years, requiring constant raising of the track. About 10 years ago the building of the dam required this rail line to be relocated. Now the fill, of the same material, but carefully selected and graded, with moisture content made just right by sprinkling, was laid down in thin layers and rolled. So hard was the resulting fill that surveyors had to use nails instead of wood stakes to mark their transit points. And when the track was laid it stayed there; no settlement, no raising. Through new knowledge of soils and wise use of equipment, maintenance costs were practically eliminated.

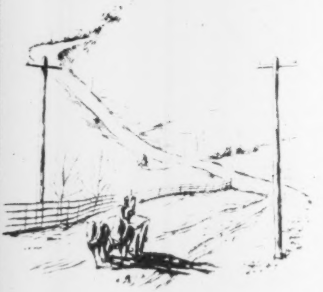
About 30 years ago a line of earthmoving equipment drawn by tractors was introduced. It was criticized as being too large, but it permitted a contractor to move earth for 12 instead of 40 cents a yard. Today such "large" equipment is only used on small jobs.



ROADBUILDING PLANT ON WHEELS leaves a ribbon of blacktop pavement behind it. Backbreaking buggying of "hot stuff" has given way to button-pushing from the driver's seat.







GREAT TURNPIKES, curving through the mountains, skirting cities, serving 40 million vehicles, have knit the nation together in a manner impossible in the days of the dirt road and the lumber wagon.

Ludlow Ferry, Md. for example. Rock was 190 ft. below water, and the water was up to 75-ft. deep. Since the bridge was two miles long, sinking caissons for each of the many piers was prohibitive in cost. The solution was to drive steel H-piles—37 miles of them. Some were 194 ft. long, the longest ever driven. Each of these piles weighed 12 tons and required a 16 ton hammer to drive it home.

Yet the long piles were only one of the spectacular innovations. Over the tops of the piles were sunk great bell-bottom steel caissons, which were filled with concrete to form the legs of the piers.

Not too many years before, this location defied the bridge builders. San Francisco Bay was another. But in its deep, swiftly running water a caisson was finally placed whose dredging wells were topped with steel domes to retain compressed air and thus control buoyancy until it could be landed. On top of this caisson is the great central anchorage of the twin suspension bridges that have speeded travel across San Francisco Bay.

Plans are dreams for the future

These achievements are compounded of know-how, courage and mechanical ingenuity. They measure the means that the civil engineer and the construction man now command to use the forces of nature for the benefit of mankind. They are far beyond what he had available in 1874 when this journal commenced publication. Then the construction man could not foresee electric power, internal combustion engines, crawler tractors, rubber-tired trucks, and many other tools that have played such a leading part in making the America of today. Today, he cannot foresee what new tools the future will bring forth, but the possibilities are enormous. That, too, augurs well for building a greater America.

Toward this great goal, too, is directed the ceaseless urge of the engineer and construction man to expand his knowledge and develop new skills. Right now his inventory of things to do lists new rustproof metals, prestressed concrete, leakproof irrigation canals, wider use of structural welding. It shows, with red underlines, safer highways through channelized traffic lanes, cheaper water supply via reclaimed sewage effluent, better buildings with the aid of thinner, insulated walls. He wants timber with just the right amount of moisture in it, design methods that don't waste material, and machinery that will do things for him never done before.

By birthright and priceless heritage he keeps the pot of progress boiling. He dreams, but in the construction man's America dreams come true.

Perhaps the real glory of the engineer and the construction man in this respect is that he is not confined. Neither his feats nor his imagination can be rooted to one spot, nor to any one land. Part of the construction man's America can be found all over the globe.

It started in May, 1904, when the United States government took possession of the Panama Canal Zone, a disease-ridden strip across the isthmus, the jungle-reclaimed evidences that men had tried and failed 15 years before to construct a canal. Here was the beginning of the export of American construction knowhow.

The Panama Canal example has been reproduced many times over. Oil for engines throughout the world is being pumped from the wells of Arabia, through pipelines laid across the burning sands by American construction men. The Shah of Iran rides over roads built by American construction men. The Communists in China are taking over some outstanding construction built by Americans. Light and power for India and Afghanistan will soon be available from American-built dams.

The great dividends of free enterprise are in demand all over the globe. It is now near the end of the first half of the 20th century—"The American Century," it has been called. And it has been the century during which a new land awakened to its strength and took its place as the leader. Leadership brings its own responsibilities. But who is responsible for America? This is such a big land, with so many glories, that perhaps properly no one group should claim credit for what is here. But the American team of civil engineers, architects and construction men could make a case.

America is unfinished; so, too, is the world. Backed up here at home is about 8½ years of construction at the 1948 record rate. In the first half of the 20th century, the American construction engineer has made his record. It is a better America than when he started. Let him dream, and build, and this land will be even better.

Let him extend his vision, raise his aspirations, embrace his opportunity. For now not only America clamors to be better; in the next half-century a world must be re-built.

THE ALMANAC

OF SIGNIFICANT EVENTS IN BUILDING A GREATER AMERICA

1874 1949

compiled by

ENGINEERING NEWS-RECORD

on its 75th anniversary

SEWAGE DISPOSAL

1876-80 Results of on-the-spot studies of European installations by C. F. Folsom and Rudolph Hering exert strong influence on American design practices.

1886 Establishment of the Lawrence (Mass.) Experiment Station. Marked beginning of sewage disposal science the United States.

1887 Dilution standard of 4 cfs. per 1,000 persons for design of Chicago Drainage Canal (designed for 3.33 cfs.) recommended by Rudolph Hering. First American attempt to define stream-purification capacity.

1887 First intermittent sand filter at Medford, Mass.

1887 Chemical precipitation used at Coney Island, N.Y.

1890 Massachusetts Board of Health report on water and sewage purification calls attention to the biological nature of sewage filtration through sand beds and stimulates improvements in intermittent filters.

1901 First trickling filter installed at Madison, Wis.

1903 Cameron septic tank used at Saratoga Springs, N.Y

1906 Sewage chlorination practice initiated with studies of Earle B. Phelps at Massachusetts Institute of Technology and later at Red Bank, N. J.

1909 Karl Imhoff's two-story settling and digestion tank appears on the American scene. This improved process together with the Cameron patent-infringement suits gradually checks use of the septic tank except for small installations.

1912 First traveling distributor for trickling filters installed at Springfield, Mo.

1912 Separate unheated sludge digestion initiated on a large scale at Baltimore, Md.

1914 Liquid chlorine applied on plant scale for disinfection of sewage at Altoona, Pa.

1915 Continuously operated, mechanically-cleaned bar screens at Sacramento, Calif., stimulate interest in reducing manual-labor needs.

1916 Fundamental concepts of stream-pollution control arise from studies begun at the Cincinnati Experiment Station by E. B. Phelps and H. W. Streeter.

1916 First activated sludge plant put into operation at San Marcos, Texas, following process development by E. Bartow, F. W. Mohlman and T. C. Hatton.

1916 Mechanical, rotating sludge-collection and removal mechanisms – developed for ore processing – adapted for sewage treatment by J. V. N. Dorr.

1920 First rotary distributor for a trickling filter put into service at Pontiac, Mich.

Chicago's Southwest activated sludge plant is designed to treat 400 mgd. of domestic, stockyard and packing wastes, the population equivalent of which is 2,250,000 persons.

A compact 0.5-mgd. high-rate sewage plant with primary and secondary clarifiers, a 40-ft. trickling filter and digester at the State Hospital at Stockton, Calif.

1922 First mechanical, drag-type sludge scraper put into service in settling tanks at Chicago's Des Plaines plant.

1923 Vacuum filtration of activated sludge successful on an experimental scale at Milwaukee, Wisc.

1925 Optimum temperature and pH ranges for sludge digestion as well as gas yields established by W. Rudolfs at the N. J. Agricultural Experiment Station.

1925 Separate sludge digestion with a floating cover to collect gas for heating sewage made practical by J. R. Downes at Plainfield, N. J.

1926 Fundamental efficiency studies on disinfection of raw and settled sewage with chlorine made by W. D. Tiedeman at Huntington, N. Y.

1926 Value of shredding sewage screening and discharging pulp back to flow demonstrated by C. E. Keefer at Baltimore.

1927 Usefulness of ferric chloride for conditioning activated sludge prior to vacuum filtration discovered by J. R. Palmer and F. W. Mohlman.

1927 Mechanically cleaned grit chamber with continuous separation of organic matter and sediment first utilized at Harrison, N. Y.

1928 Engines burning sludge gas used at Charlotte, N. C.

1929 Filtration of raw, digested and mixed sludges successfully demonstrated at Salem, O.

1931 First activated-sludge thickener. Phoenix, Ariz.

1932 First large-scale pilot-plant for dewatering and burning filter cake operated at the West Side plant of the Sanitary District of Chicago. This led to flash drying and incineration of all types of sewage sludge.

1933 An external heat exchanger on a sludge digester first employed at Coatesville, Pa.

1933 Smaller chemical dosages and higher filter yields result from elutriation of digested sludge prior to vacuum filtration. Developed by A. L. Genter.

1933 Revival of chemical precipitation sparked by construction of Shades Valley plant, Birmingham, Ala. This was followed in 1935 by the Dearborn, Mich. plant – notable for its sludge-handling and other mechanical features.

1934 Experiments on combined garbage and sludge digestion by C. E. Keefer are a prelude to establishment of a central garbage-grinding station at Baltimore, Md.

1935 Dewatering digested primary sludge by vacuum filtration adopted on plant scale at Springfield, Ohio.

1936 First high-rate filtration plant installed at Camarillo State Hospital, Calif. Outcome of work by H. W. Jenks and H. O. Halvorsen.

1936 Flocculation of raw sewage without chemicals demonstrated on plant scale at Cedar Rapids, Ia.

1939 World's largest activated-sludge installation, Chicago's Southwest plant, begins operation.

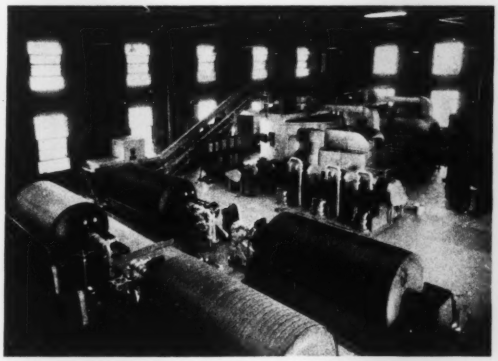
1939 Step aeration is incorporated in New York's Tallman's Island activated-sludge plant by R. H. Gould.

1941 First vacuum flotation unit at San Diego, Calif.

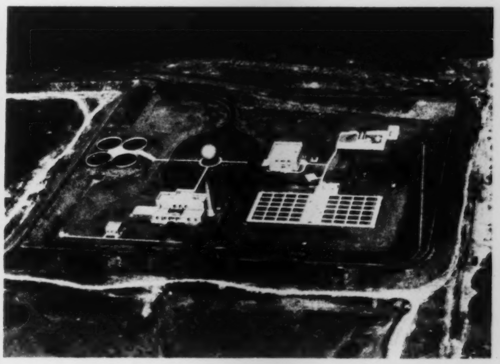
1943 Operation of New York's Jamaica plant switched to modified aeration process (high-rate activated sludge).

1948 Federal stream-pollution-control law enacted 50 years after the first bill was introduced.

1949 Combined coagulation and sedimentation treatment of sewage using water-plant sludge as the coagulant put into operation at Daytona Beach, Fla.



Dewatered on vacuum filters, sludge from Imhoff tanks at Cleveland's Westerly sewage treatment plant is belt-conveyed to an incinerator for disposal.



Treatment at Springfield, Mass. consists of only grit removal and settling, but sludge is digested, elutriated, vacuum filtered and burned. The spherical tank is for sludge gas.

(McLaughlin Air Service photo)

WATER SUPPLY

1883 Croton Aqueduct Commission organized. This predecessor of the N. Y. City Board of Water Supply had by 1890 completed the project which set precedent for long aqueducts of later years.

1888 Stream gaging begun by U. S. Geological Survey.

1891 Publication of the "Manual of American Water Works" by M. N. Baker assembles for the first time significant data on U. S. systems.

1892 First Venturi meter used on a municipal water project at Newark, N. J. This project also marked the first use of large diameter (42-in.) steel pipe.

1895 Metropolitan Water Board – the forerunner of large water authorities – created to construct, operate and maintain waterworks for Boston.

1902 First high-pressure mains for fire fighting installed by city of Philadelphia.

1902 Standard specifications for cast-iron pipe and specials adopted by the New England Water Works Assn. (by the AWWA in 1908).

1904 Results of studies for New York's water supply are issued in classic reports destined to serve as "textbooks" for later investigations.

1913 Los Angeles Aqueduct completed to convey water from Owens River, 233 miles away.

1908 The great works of the Catskill water supply system for New York City completed.

1910 Relation of spread of typhoid fever to sewage-polluted interstate waters studied by Public Health Service.

1913 Large reinforced-concrete pipe (9-ft. dia.) first used for delivery of water under pressure at Baltimore.

1920 Centrifugally cast pipe as well as cement-lined pipe brought on the market.

1920-25 Development of high-efficiency, electric-motor-driven centrifugal pumps results in gradual replacement of steam-driven reciprocating units.

1921 Report on causes of electrolysis and its effects on water pipes issued by the American Committee of Electrolysis.

1926 Bay Crossing Aqueduct brings water to San Francisco peninsula. First step in a vast water-supply project is completed after a 26-yr. struggle.

1930 The flood hydrograph, which led to the unit hydrograph and other important relationships for reservoir studies and spillway designs, first developed in a committee of the Boston Society of Civil Engineers.

1932 Asbestos-cement pipe first used on a large scale to combat corrosion and electrolysis at Winnipeg, Canada.

1934 Water from the Hetch Hetchy reservoir flows through a 155-mile aqueduct and arrives on San Francisco peninsula – 33 years after first appropriations were made.

1934 First inventory of the nation's water needs is made by National Resources Board.

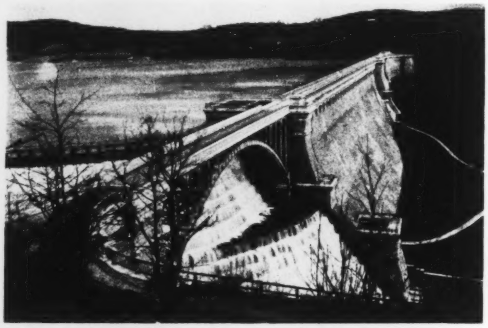
1936 Development of a Delaware River supply for New York City starts with construction of the 85-mile aqueduct.

1937 First water drawn from the west slope of the Rocky Mountains through the Moffat tunnel initiates a large-scale, long-range supplemental program for Denver, Colo.

1941 The great 1,600-sec. ft., 400-mile Colorado River Aqueduct completed by the Metropolitan Water District of Southern California.

1940 Cement lining of cast-iron pipe in place started in the United States at Charleston, S. C. and Falmouth, Mass.

1947 Lake Huron water pumped through an 80-mile, 70-mgd. conduit to Saginaw and Midland, Mich.



Main reservoir of New York City's Croton water supply system—with 33,800 mg. of available storage capacity—is formed by the famous New Croton Dam, completed in 1905.

WATER PURIFICATION

1872-74 Slow-sand filters introduced to America in plants at Poughkeepsie and Hudson, N. Y.

1880-85 Development of rapid sand filters started in the United States by a number of engineers and manufacturers.

1892 Confidence in water filtration built up by investigations at the Lawrence Experiment Station as well as by Allen Hazen's basic research on filtration performance.

1893 First iron-removal plant – double filtration through sand and bone charcoal without chemical treatment or aeration – is put into service at Atlantic Highlands, N. J.

1894 Tastes and odors correlated with various micro-organisms by Desmond Fitzgerald's studies on Boston's water supply. These data become useful after copper-sulfate treatment for algae control is discovered in the twentieth century.

1896 Iron removal by milk of lime, aeration and filtration practiced at Reading, Pa.

1899 George W. Fuller issues classic reports on tests of rapid sand filtration at Louisville and Cincinnati.

1902 First municipal water-softening plant in America – utilizing the Porter-Clark process – put into service at Winnipeg, Canada.

1902 New era in water treatment begins with construction of rapid sand filters in reinforced concrete tanks at Little Falls, N. J. This encouraged rapid sand filtration with consequent reductions in typhoid-fever rates.

1905 Rapid adoption of copper sulphate as an algicide for reservoir treatment follows completion of significant experiments by G. T. Moore and K. F. Kellerman.

1908 Use of hypochloride of lime as a water disinfectant given impetus by large-scale application at Jersey City's Boonton reservoir and by G. A. Johnson's experiments at Chicago.

1910 First ozonation plant for water disinfection on the American continent put into service at Lindsay, Ontario.

1910 Liquid chlorine successfully used as a water disinfectant at Fort Meyer, Va.

1916 High velocity filter back washing, worked out by J. W. Ellms and J. S. Gettrust at Cincinnati, destined to replace rakes and compressed air within ten years.

1922 Initiation of hydrogen-ion control paves the way for great improvement in water coagulation.

1924 Practical, accurate laboratory equipment for determining turbidity in water, perfected by John R. Baylis, provides a means for improving clarity of filtered water.

1924 Experiments at Baltimore initiate widespread use of surface wash as an adjunct to filter back washing.

1925 First large zeolite softening plant put into operation by the Ohio Valley Water Co. at Pittsburgh.

1926 Superchlorination on a large scale started by N. J. Howard and R. E. Thompson at Toronto, Canada.

1926 Chlorine-ammonia treatment for taste-and-odor control, imported from England, employed at Greensville, Tenn.

1928 Phenomenon of "break-point" chlorination reported by R. D. Scott.

1929 Wide acceptance of activated-carbon addition to reduce objectionable tastes and odors follows first successful experiments by J. R. Baylis.

1931 Threshhold test for odors first employed by C. H. Spaulding.

1935 Interest in upward-flow reaction and sedimentation revived by C. H. Spaulding in designing and operating a softening plant at Springfield, Ill.

1942 Diatomaceous-earth filtration for small quantities of water perfected for military use.

1941 World's largest zeolite softening plant put into operation by the Metropolitan Water District of Southern California.

1942 World's largest filtration plant (320 m.g.d.) built at Chicago to treat Lake Michigan water.

1944 Chlorine dioxide treatment to eliminate phenol waste tastes and odors successfully started at Niagara Falls.

1945 Ten-year investigation of tooth-decay prevention by adding fluorine to water started at Newburgh and Kingston under sponsorship of the N. Y. State Department of Health.

1948 Electron microscope research at Chicago's South District filtration plant seeks rapid identification of pollution-index organisms.

1949 Publication of the "Quest For Pure Water" by M. N. Baker – an outstanding waterworks history – fills a long-needed gap in sanitary engineering literature.

FOUNDATIONS

1874 First large and deep pneumatic caissons completed for Eads Bridge at St. Louis and begun on Brooklyn Bridge at New York. With later perfection of process by Geo. S. Morison on his several Missouri and Mississippi River bridges, precedent was set from which only changes in detail have occurred in 75 years.

1874 Publication of "Method of Isolated Piers" by Frederick Baumann of Chicago. First statement of scientific foundation principle for building foundations – centroid of footings must be coincident with resultant of column loads. Led to abandonment of continuous spread footings and thick floating mat foundations.

1875 Vulcan introduced steam pile hammer in U. S.

1882 First steel grillage (of rails) used in footings of Montauk Building in Chicago. Permitted reduction in size of foundation piers which theretofore had occupied most of basement. By 1886, rails were superseded by I-beams in footings for Tacoma Building in Chicago, and by 1900 reinforced concrete footings appeared.

1887 Wakefield timber sheetpiling patented. Made cofferdam construction easier and tighter.

1888 Publication in Engineering News of A. M. Wellington's pile-driving formula, later known as Engineering News formula. Modified for heavier piles and for steam hammers, it is still widely used, even though more scientific "dynamic type" formulas have been developed.

1888 Open-dredged caisson in first large box type, 60 x 100 ft., put down 134 ft. below water for Hudson River railway bridge at Poughkeepsie, N. Y. Concrete deposited underwater with automatic-opening buckets.

1893 Use of long piles to hardpan under piers of Northern Pacific station (now B&O) in Chicago by S. S. Beman provided the unyielding supports that the developing skyscraper required.

1893 Introduction of pneumatic caissons, equipped with new Moran airlock, to building foundations occurred on Manhattan Life building in lower New York. Not until 1927 was any other method used for skyscrapers in areas where rock was overlaid by water-bearing material.

1893 Introduction of double-acting steam pile hammer by McKiernan-Terry.

1894 "Chicago method" for penetrating tight clay, by driving vertical lagging as excavation progressed, introduced by Wm. Sooy-Smith on Chicago Stock Exchange. Widely used since. A later variation introduced by Charles R. Gow used telescoping steel cylinders in place of lagging. An essential part of Gow caisson technique was to bell out bottom of excavation to provide increased bearing area.

1896 Underpinning with steel pipe, jacked down and concrete-filled, introduced in New York. Greatly perfected twenty years later by Lazarus White.

1900 Walls formed by series of pneumatic caissons sunk around Mutual Life building in New York by Alfred Noble and T. Kennard Thomson. Joined by Daniel Moran's concrete-filled pneumatic joint, these caissons excluded water, thus making large, deep basements possible.

1901 Cast-in-place concrete pile invented by A. A. Raymond. Gave impetus to development of many other types over the years. Precast piles originated earlier in Europe, and patented designs of this type also appeared.

1908 Lackawanna steel sheetpiling introduced. With an interlock detail as an integral part of the piling, it permitted tight, strong cofferdams to be built quickly and efficiently.

1908 H-section steel pile put on market; superseded I-sections, first used about 1900 on trestles in Nebraska. Furnished new type of high-capacity foundation.

1910 Cellular cofferdam of interlock steel sheetpiling developed for raising battleship "Maine." Precedent thus set followed many times later for bridges, dams, locks, etc.

1913 Freezing process used on department store foundation in Berlin, Germany, to permit excavation through water-bearing sand.

1925 Publication in Engineering News-Record of series of articles by Karl Terzaghi heralded a new era of scientific understanding and study of the strength and behavior of sand and clay – the beginning in the U.S. of the science of soil mechanics, although some of its practices, largely following Rankine's principles, had previously been in use.

1926 First trial of open-air work for piers in water-bearing formations made on Harriman Building in downtown New York. Steel sheet piles sealed into hardpan established that compressed air was not always necessary for such sites. Set pattern for many subsequent buildings. Year later a useful variation introduced on Greater Penobscot Building in Detroit, where Moran airlock was installed to bottom out open piers.

1926 Wellpoints used to predrain sand and aid open-cut basement excavation on Harriman Building in New York. Greatly expanded use of wellpoints followed.

1927 Steel sheetpile cofferdam, 98 x 109 ft. in area, used for west pier of George Washington Bridge at New York to withstand 79 ft. head of water. It established cofferdams as competitors of caissons for deep, open work, influencing their adoption for 97 ft. depths on Lake Champlain bridge and for 101 ft. at one San Francisco-Oakland bridge pier.

1930 Sand islands built up at pier locations for Southern Pacific's Suisun Bay bridge in California permitted caissons to be sunk as on land.

1930 Principle of equalizing weight of excavated material with weight of structure to be supported (to eliminate settlement in compressible soils) introduced on Albany telephone building. Basement and first floor slabs joined by Vierendeel-truss walls to form a box foundation of floating type.

1933 Open caisson sunk deeper than ever before, through 90 ft. of water and 80 ft. of sand and gumbo for Huey Long Bridge at New Orleans. Jets in all walls were used to overcome skin friction. To reduce the bearing pressure the dredging wells were left open except for seals of tremie concrete at the bottom.

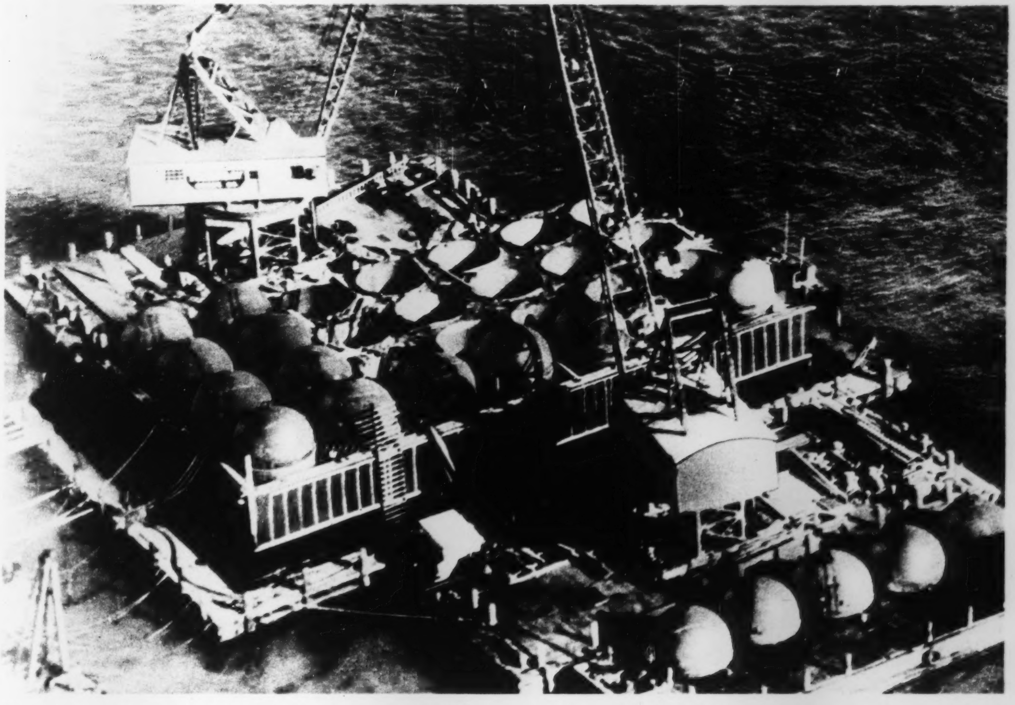
1935 Clamped to a rotating head, steel cylinders, 4 to 8½ ft. dia., with saw-tooth cutting edges, were drilled and jetted through clay and boulders for foundations of Church St. post office in New York. Large cylinders carry 3,500-ton loads.

1936 New type open caisson, a 92 x 197 ft. box designed by Moran & Proctor, in which dome coverings over dredging wells permitted the use of compressed air to control flotation, was sunk to record depth of 224 ft. for great central anchorage of San Francisco Bay Bridge. Method permits almost unlimited flotation depths for caissons.

1936 Open caissons (80 x 135 ft.) carried to record depth of 242 ft. on Bay Bridge at San Francisco.

1937 Socketing foundations a few feet into bedrock introduced by Western Foundation Co. on a New York City garage. Greatly increased capacity of the foundation columns (concrete-filled cylinders with steel H-cores) by supplementing direct bearing with bond action in rock. Such foundations, known as drilled-in caissons, were sunk 202 ft. below water level to carry 900 ton loads for lift bridge at Cleveland.

1940 Steel H-piles of record length of 194 ft. driven by record size 16-ton hammer for piers of Potomac River bridge, Ludlows Ferry, Md. Caissons floated in on top. Opened up new possibilities for extremely deep foundations.



Most spectacular foundation job of modern times was the sinking of the 92 x 197-ft. caisson for the central anchorage of the San Francisco Bay Bridge. Built with 55 cylindrical dredging wells, the caisson was controlled during sinking by capping some of the wells with domes and excluding the water by compressed air—an improvement over the false bottoms previously used.

BUILDINGS

1876 Thaddeus Hyatt experimented with reinforced concrete beams and pioneered a design theory. Although he was preceded in this work by Joseph Monier, who was issued a patent in 1857 in France, his success led to the widespread development of reinforced concrete in the U. S.

1885 Ten-story Home Insurance Building built in Chicago, first approach to skeleton form of construction. Architect W. L. Jenney set the cast iron columns in the load-bearing masonry piers to support the wrought-iron floorbeams.

1885 First steel beams rolled.

1887 True skeleton construction, eliminating masonry bearing walls, used on the two street frontages of the 12-story Tacoma Building in Chicago by architects Holabird & Roche.

1889 Rand McNally Building, Chicago, employed steel columns throughout. Up to this time, cast iron was used.

1892 Masonic Temple was built in Chicago to a height of 21 stories (273 ft.) demonstrating fully the possibilities of the skeleton type of construction. Following this, its use spread to New York and other cities.

1893 Construction of the museum building at Leland Stanford, Jr., University, Palo Alto, Calif., by E. L. Ransome, demonstrated the practicability of monolithic concrete construction. Most of the major concrete buildings erected during the next decade were based on the patents of Ransome, and of the Frenchmen, Hennebique and De Valliere.

1903 Sixteen-story Ingalls Building in Cincinnati completed, first skyscraper of reinforced concrete in the U. S. World's record is now held by the 34-story, 507-ft. high Banco do Estado de Sao Paulo office building in Brazil, completed in 1946.

1906 Wide-flange steel beam and column sections introduced. This development coincided with the rising ratio of cost of fabrication labor to cost of materials, and consequently was of considerable economic significance.

1913 Woolworth Building in New York City, setting a height record that was unbeaten for 16 years, became one of the best known office structures in the world. It is 58 stories (760 ft.) high.

1915 A series of articles on wind stresses by Robins Fleming, published in ENGINEERING NEWS, formalized procedures – the cantilever and portal method – for analyzing multi-story building frames without diagonals. For the next dozen years, all buildings were designed by these methods.

1916 New York City passed a zoning ordinance limiting the height to which buildings could go without setbacks. This law set the pattern for other cities and basically influenced building architecture.

1920 A mill building in Brooklyn was the first building of appreciable size to be erected with welded steel frame.

1925 Earthquake at Santa Barbara, Calif., led to development of provisions for seismic-resistant design that were adopted as a code by the Pacific Coast Building Officials Conference. Following the Long Beach earthquake in 1933, California passed laws making seismic provisions mandatory, and set the pattern for legal action in other earthquake zones, greatly influencing the structural design of tall buildings.

1926 American Welding Society committee under Leon Moisseiff and Malcolm Priest began investigation of strength of structural welds. The report, five years later, provided the scientific basis for both design and code drafting.

1928 Freyssinet used high-strength steel for prestressing concrete. Although prestressing had been introduced by P. H. Jackson of San Francisco in 1886, it had not proved practicable because of the relatively high loss of prestress due to creep and plastic flow when low yield-point steel was used.

1930 Publication by H. V. Spurr of method of wind analysis to eliminate vibration in super-tall buildings – based on limiting deflection and using wind pressures that increase with height. Suction forces were also taken into account.

1930 Erection of 19-story all welded Dallas Power & Light Co. building. Using new coated electrodes, it gave assurance that welding was safe.

1931 The 85-story, 1,250-ft. high Empire State Building – the world's tallest – was completed in New York City. Since then, little consideration has been given to erecting higher structures because of the difficulty in renting the large amount of space and in transporting the associated high density of population.

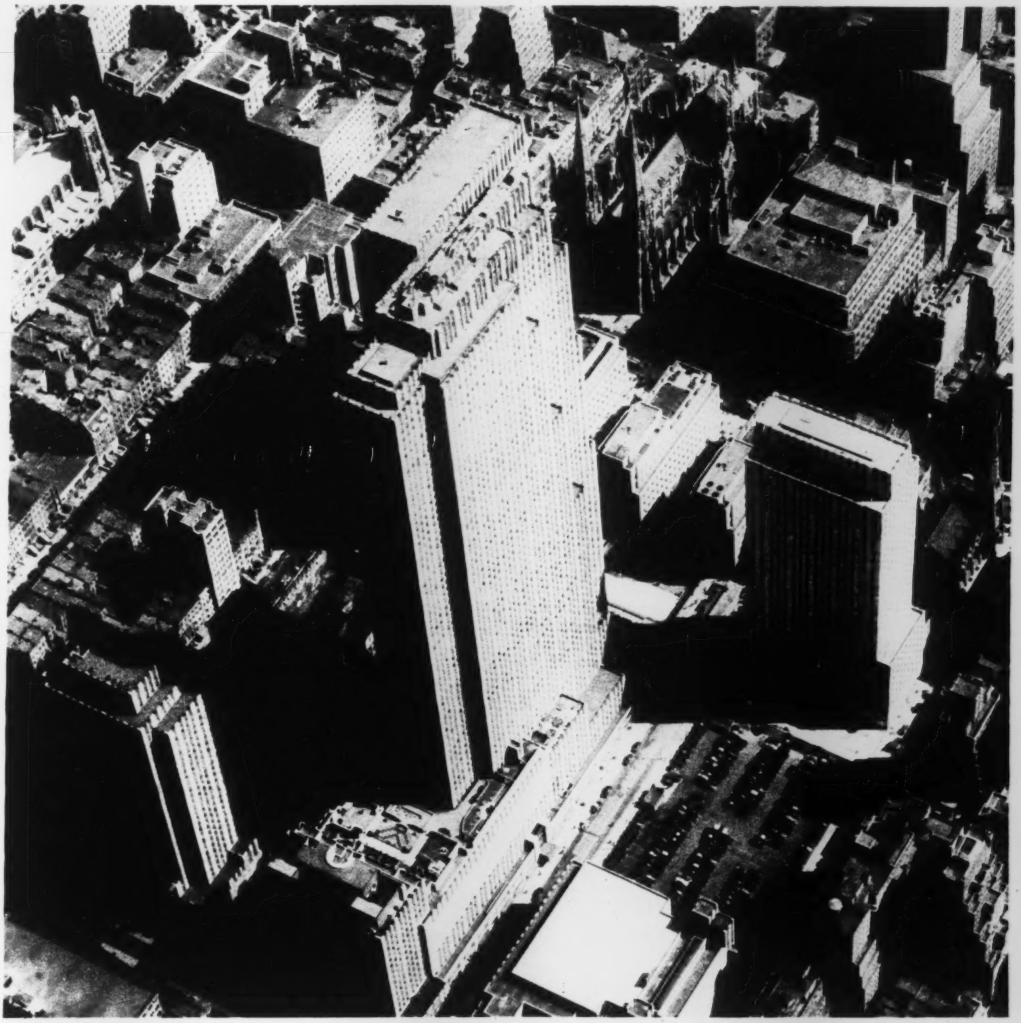
1931 Inauguration of Rockefeller Center project in New York City to include a group of nearly a dozen large office and theater buildings on a three-block site. Introduced the concept of group planning of commercial buildings, of low buildings alternating with high towers to achieve light and air, and of integrated underground communication between buildings.

1931 First windowless air-conditioned factory started at Fitchburg, Mass. for the Simonds Saw & Steel Co. Before it was completed in 1939, a small, windowless office building was erected at Wallingford, Conn., and a larger one for Hershey Chocolate Corp., at Hershey, Pa. (1936).

1933 Introduction of split-ring connectors for joining timber members made longer timber truss spans possible.

1935 Hayden planetarium (80-ft. span) in New York City introduced thin-shell dome roof construction in the U. S. First of this type was the planetarium at Jena, Germany, constructed in 1924. Since then, thin-shell roofs as arches have been developed much farther, with a record-breaking span of 340 ft. being used for hangars at Rapid City, S. C., and Limestone, Me., in 1949.

1947 The 24-story City National Bank of Houston, Texas, established a record height for all-welded buildings.



Rockefeller Center set a new note in building architecture by concentrating a large part of its floor area in sheer-walled towers devoid of setbacks. Gardens on the lower roofs are another innovation. The great central building contains slightly more floor area and steel tonnage than the Empire State Building. Wind loads controlled the design of its 103 x 327-ft. tower, 832-ft. high.

(Aerial Exploration photo)

BRIDGES

1874 First general printing of Squire Whipple's twenty-five-year-old book "A Work on Bridge Building," wherein stresses were first correctly analyzed. This book, plus the development of wrought iron to replace cast iron and wood, marked the beginning of scientific bridge building.

1874 Completion of Eads Bridge at St. Louis. First use of steel in an American bridge (here a chromium alloy for the 520-ft.-span tubular arch ribs).

1875 Specifications, prepared by engineers to guide bidders, appeared for first time. Inaugurated by engineers of Cincinnati Southern Ry. Co., specifications marked end of competitive designs by fabricating companies.

1876 Collapse near Ashtabula, Ohio, of a 154-ft. span wrought-iron Howe truss with cast-iron joint boxes. Emphasized lack of knowledge of design and materials; led to laws placing responsibility for bridge safety on the railroads, which in turn brought the consulting bridge engineer into being.

1877 First all-structural-steel bridge built over Missouri River at Glasgow, Mo. Its five 315-ft. truss spans proved success of this great new metal, and made Hay, the manufacturer and Sooy Smith, the bridge designer, lastingly famous. Within three years Geo. S. Morison began building steel truss spans over the Missouri, Mississippi and Ohio rivers each longer than the one before until by 1890 he reached 520 ft. in the Merchants Bridge at St. Louis.

1879 Tay Bridge disaster in Scotland, in which 13 truss spans, each 200-ft. long, were blown from high piers by an 80 mph. wind. Gave rise to study of wind forces and effects.

1883 Michigan Central Railroad Niagara Gorge span completed. Established the cantilever, a German invention, as one of the most popular U. S. truss types.

1883 Brooklyn suspension bridge of John and Washington Roebling completed. Introduced steel wire for bridge cables, and a spinning and squeezing procedure that has since changed only through better mechanization.

1890 Firth of Forth cantilever of two 1700-ft. spans completed in Scotland. Focused attention on lessons of Tay disaster by heavy design to resist wind — using 56 lb. per sq. ft. compared to the later norm of 30 lb.

1894 Movable bridges in three new types: London, a double-leaf 200-ft. span bascule in the Tower Bridge; Chicago, a Scherzer rolling bascule at W. Van Buren St.; Chicago, Waddell's 130-ft. lift span at S. Halstead St. These bridges, plus the first under-floor-counterweight trunion-bascule at W. Clyburn Place, Chicago, set off a great development era in movable bridges.

1895 Report of Austrian Society of Engineers and Architects established scientific design of concrete arches on basis of elastic theory.

1897 Reinforced concrete entered U. S. bridge field with Melan type (structural steel reinforcing) arches of 125-ft. span in Kaw River Bridge at Topeka, Kan. Followed European precedents not only by Melan but by Hennebique, Moller, Monier and Wausch.

1906 Walnut Lane Bridge, Philadelphia, set precedent for all modern concrete arches in U. S. with its 280-ft. bar-reinforced span in which ribs rather than a barrel arch carried the roadway. Followed precedent of 164-ft. arch at Chatellerault, France, built in 1899.

1907 Collapse during erection of one 500-ft. anchor arm of the 1800-ft. span Quebec cantilever when lower chord, inadequately latticed and spliced, buckled. Spurred research and study on design and proportioning of compression members and truss connections.

1908 Riveted joints to replace pins given first big impetus by Armour-Swift-Burlington Bridge at Kansas City.

1909 Manhattan suspension bridge completed over East River at New York was first designed in U. S. on basis of later widely-used deflection theory, in which dead weight is considered as reducing live load distortions. Also marked introduction of fixed cable saddles, of slender towers with fixed bases and nickel steel for high-strength members.

1910 McKinley Bridge, St. Louis, completed, in which Modjeski abandoned use of eyebars for tension members taking reversed stresses. The start toward all-riveted trusses.

1916 Completion of 977-ft. Hell Gate Bridge at New York carried the steel arch to new dimensions of span length and weight, and inaugurated practice of extensive use of parts of permanent structure for erection staging. Marked great advance in erection equipment to handle heavy members, some weighing 185 tons.

1917 Silicon steel, now standard for large bridges, introduced in the Metropolis, Ill. bridge whose 720-ft. simple truss span is still the longest of this type ever built.

1917 In continuous truss — two 775-ft. spans — at Sciotoville, Ohio, Lindenthal provided a precedent for extensive use of this type design. As one of the last U. S. bridges to be erected with a gantry crane, Sciotoville also marked a turning point away from costly erection falsework and toward the use of light steel-setting travellers and cantilever erection.

1922 Rigid frame concrete spans developed for Westchester County, N. Y., by Hayden. Revived a long-neglected structural principle. Provided the pattern for hundreds of grade-separation bridges built since in both concrete and steel.

1926 American Institute of Steel Constuction began its annual awards for beauty in bridges, which had a continuing and marked effect on design.

1926 Philadelphia-Camden suspension bridge, doubled diameter of 15-in. Brooklyn Bridge cables, thus eliminating a mental hazard that had held back big bridge projects since the Quebec bridge collapse.

1927 Rock Island Lines lift bridge at DeVall's Bluff, Ark., placed operating machinery on towers instead of in center of span itself. Also introduced the use of synchronizing or tie motors to keep all corners of span level while raising or lowering.

1930 Concrete arch of 612 ft. completed at Plougastel, France, dramatized possibilities of hollow-section ribs, both for arches and girders. Made possible the 866-ft. span Sando arch in Sweden in 1947, and the 253-ft. girder span in the Waterloo Bridge in London in 1946.

1931 Steel arch extended to 1,652 ft. at Bayonne, N. J. and Sydney, Australia. Bayonne introduced the use of wire rope suspenders in place of built-up structural members susceptible to wind damage.

1932 Completion of George Washington Bridge over Hudson at New York. Doubled span length and nearly tripled total cable volume over previous record. With four 36-in. dia. cables on a 3,500-ft. span without a stiffening truss, it demonstrated the inherent stiffness available to a long span heavy suspension bridge in its cables and suspended roadway. Introduced use of machinery to drive and brake the huge reels of wire, speeding up spinning process; also practice of pre-stressing suspender ropes to minimize permanent stretch.

1932 Open-steel-mesh roadway on University Ave. bascule in Seattle. Stimulated development of light-weight floors, including concrete-filled steel grid.

1936 Plate girder type arch ribs, previously reserved for short spans, extended to 800 ft. on fixed-end Henry Hudson arch at New York, and (by 1941) to 950 ft. on Rainbow arch at Niagara Falls.

1936 Welded bridge specification published by American Welding Society. Accelerated use of welding – widely for details, frequently for entire small and medium-size structures.

1937 Golden Gate Bridge extended suspension spans to 4,200 ft. Towers, omitting diagonals, and designed as rigid frames, carried farther a new architectural note first introduced in 1931 in the much smaller Waldo-Hancock Bridge in Maine. Cable spinning reached new records of efficiency and speed; by use of triple spinning wheels and double tramways, 24 wires placed in each trip, six times number on George Washington Bridge.

1939 Plate girders entered long span service (250 ft.) at Perth Amboy, N. J. By 1941, there was a 300-ft. span at Hartford, Conn., and by 1948 a 605-ft. span (hollow-section type) over the Rhine at Cologne, Germany.

1940 Failure of 2,800-ft. span Narrows suspension bridge at Tacoma, Washington, revealed danger of too great flexibility. Stimulated research into aerodynamic stability of suspension structures.

1948 First all-aluminum bridge – a 121-ft. span double-leaf bascule – complete at Sunderland, Eng. A few months earlier a 100-ft. plate girder railroad span was erected at Massena, N. Y., and work was starting on a 290-ft. highway arch at Arvida, Quebec.

1949 First prestressed concrete girder (160-ft. span) in U. S. was begun in Philadelphia.

George Washington Bridge at New York was opened with six traffic lanes, now has eight. Provision was made in the design for a future lower deck that can accommodate four electric railway lines. Largest, although not the longest, of the world's suspension bridges, it has a main span of 3,500 ft. and is carried by four 36-in. diameter cables with a combined strength of 350,000 tons.

CONCRETE DAMS

1884 Completion of Bear Valley Dam in California, a masonry arch 64 ft. high with crest thickness of only 3 ft. For many years inspired arch dam designers and was rated "the boldest and most adventurous of engineering structures."

1890 Placement of concrete in interlocking blocks in Crystal Springs Dam in California. The forerunner of now-standard alternate block construction.

1900 Grouting of foundation for Tallahassee Dam in Florida. This practice, improved on later jobs, made it possible to build dams on fissured foundations. Pioneer work in grouting was done on Holter Dam (Montana, 1910) and Bow River Dam (Canada, 1910). Stage grouting, developed much later, was applied extensively at Hoover Dam in 1933.

1903 First dam of the concrete slab and buttress type built at Theresa, N. Y. It was designed and built by N. F. Ambursen under patents issued to him.

1904 Arch and crown cantilever method of stress analysis applied to Pathfinder and Shoshone dams, supplementing simple cantilever analysis for massive gravity dams and cylinder formulas for arches.

1906 Allowance for uplift in dam design first made in U. S. on Wachusett Dam in Massachusetts.

1907 Building the spillway in alternate sections to full height – by-passing the river through the remaining opening – inaugurated on McCall Ferry Dam, Susquehanna River.

1908 Lake Hume Dam completed in California introduced multiple arch type in U. S. and was the model for some 30 built since.

1910 Cyclopean concrete (one- or two-man stone) was used in numerous gravity dams, notably Shoshone, 1910; Roosevelt, 1911; Pathfinder, 1913, all for the Bureau of Reclamation; and Kensico, 1916, for N. Y. Board of Water Supply. In a few years this was deemed uneconomical; was replaced by large cobbles in the aggregate – 6-in. in American Falls Dam in Idaho in 1927 and 9-in. in Hoover Dam.

1912 Foundation failure at Elwha River Dam in Washington stressed the fact that 80 percent of dam failures result from foundation causes.

1914 Copper water-stops, backed by drain wells, near upstream edges of transverse joints introduced on Arrowrock Dam in Idaho, whose 349-ft. height set a new record.

1914 Intergrinding of sand and cement at Arrowrock and Elephant Butte dams was forerunner of later use of admixtures to improve concrete quality.

1914 Salmon Creek Dam in Alaska marked introduction of the constant-angle or variable-radius arch design.

1924 First large scale field use of water/cement ratio in concrete proportioning at Black Canyon Dam in Idaho.

1925 Stevenson Creek test dam in Southern California, built to test theories of deflection and stress distribution, gave confidence for later economies in design of thin-arch barrels. A few years later, Bureau of Reclamation used this dam and Gibson Dam as prototypes for small scale models, which established structural models – of concrete, plaster, rubber and other materials – as necessary aids to dam design.

1926 Grouting of transverse contraction joints first used at Gibson Dam in Montana, with grout stops at upstream and downstream edges of joints.

1928 Strain meters embedded in the concrete of Owyhee Dam in Oregon provided data that strengthened confidence in assumptions about internal stresses. The 417-ft. height of this dam was not exceeded until Hoover Dam was built.

1928 Pipes put in Owyhee Dam for grouting concrete joints were used for experiments in circulating cooling water. Results encouraged full-scale pipe cooling at Hoover Dam.

1928 Collapse of St. Francis Dam caused California to pass a law requiring dam design to conform strictly to rules administered by a state engineer of dams. A few states had required state supervision as early as 1880, but the St. Francis failure brought an end to uncontrolled dam designing.

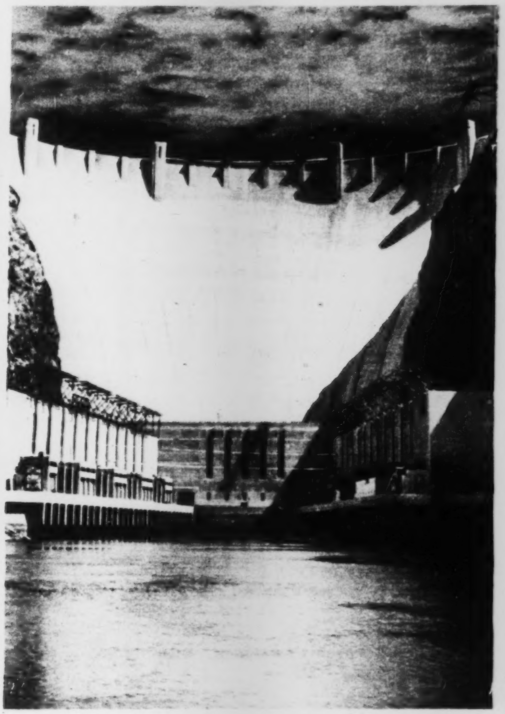
1928 Concrete chuting reached its peak in Diablo Dam in Washington. Introduced in 1910 this wet-mix placement thereafter succumbed to the new demand for low-slump concrete to be placed by bottom-dump bucket, as at Chute a Caron Dam in Quebec in 1929.

1929 Model studies for Bridge River Dam in British Columbia gave effective aid in predicting hydraulic jump effects, and on Conowingo Dam in Maryland accurately indicated where and how erosion below the dam would develop.

1930 Hydraulic model testing of shaft spillways for Hoover dam established such laboratory work as a basic necessity in dam design.

1930 Low-heat cement used in Hoover Dam where, for still further reduction of temperature, a refrigeration plant

Remains of St. Francis Dam, Los Angeles water supply structure whose spectacular foundation failure in 1928 cost 450 lives and nine million dollars. A curved gravity dam, it was 205 ft. high and 650 ft. long.



Hoover Dam is not only the highest, but the most significant dam in the world from the standpoint of design and construction innovations. All concrete dams built since 1930 have benefited from its pioneering.

chilled water for circulation through a pipe grid embedded in each 5-ft. concrete lift.

1931 Longitudinal joints introduced at Hoover Dam, divided the dam into 50x50-ft. blocks, which, with 5-ft. lifts, has become standard construction. The 726-ft. height of this dam is still the record.

1933 Concrete placed with aid of vibrators (both internal and platform type) on Pine Canyon (Morris) Dam for Pasadena water supply. Permitted use of drier concrete, saving in cement, and better placement of concrete in difficult spots.

1934 Drilling large cores (36-in. dia.) at TVA's Norris Dam made it possible for engineers and geologists to be lowered into the core drill holes to examine and photograph undisturbed formations.

1935 As cubical content of dams increased toward Grand Coulee's 10,500,000 cu. yd., new construction techniques were developed in two fields: (1) Cofferdams of unprecedented size and depth and (2) plant for delivering concrete at unprecedented rates. Two Grand Coulee cofferdams each unwatered 60 acres and into them went concrete from plant organized to deliver 300,000 cu. yd. per month.

1936 Bonneville Dam inaugurated the practice (on large dams) of mixing puzzolanic admixtures with the cement.

1940 Absorptive form lining was used at Friant Dam in California to produce dense surface concrete. Also mixing water contained chipped ice to aid in lowering initial temperature.

1940 Cracking and deterioration of apparently good concrete in Parker Dam on Colorado River found to result from destructive reaction (discovered a year earlier in concrete pavements) between alkali of the cement and any soluble silicates in the aggregate. Result: Specifications limiting the alkali content of the cement and requiring a puzzolanic addition when it is impracticable to avoid the use of potentially reactive aggregates.

1943 Dense surface imparted to spillway of Shasta Dam by use of vacuum mats, which through atmospheric pressure and suction removed excess water from the concrete. Such use of vacuum mats was extensive by 1949.

1946 Air-entrained concrete used by Corps of Engineers in Allatoona Dam in Georgia and by Bureau of Reclamation in Angostura Dam in Wyoming.

EARTH AND ROCKFILL DAMS

1875 San Leander Dam, Oakland, Calif., introduced a new scale of height to earth embankments. Originally built to a height of 115 ft. it was later raised to 125 ft.

1876 First Bowman Dam in California, a loose-rock fill with dry rubble faces, raised to record height of 100 ft. Timber diaphragm on upstream face provides watertightness. (Replaced by new dam downstream in 1926)

1889 South Fork Dam above Johnstown, Pa., an earthfill 76 ft. high built without engineering supervision, failed by overtopping, causing worst flood disaster in history of this country.

1897 Lower Otay Dam in California, a rockfill 135 ft. high, built with a steel plate corewall protected by concrete.

1901 Skaguay Dam in Colorado, 70 ft. high rockfill, equipped with steelplate diaphragm on upstream face, first of its kind.

1906 Relief Dam, a rockfill 140 ft. high on Stanislaus River in California, built with reinforced-concrete slab on upstream face for watertightness.

1912 Gatun Dam, 115 ft. high, at Panama completed. Containing 22,930,000 cu. yd., it stepped up size of earth dams many times.

1914 Ashokan dikes built by New York City Board of Water Supply, maximum height 119 ft., marked new advance in design of earthfills. Concrete corewalls at centerline. Embankment material made of a glacial drift and outwash ranging from fine silt to coarse cobbles; coarse cobbles being segregated and placed near outside slopes.

1919 Work begun on hydraulic fill dams for Miami Conservancy District in Ohio. Attention given to grading of fill material marks new advance in design methods. Many improvements made in hydraulic equipment and placing methods.

1924 Davis Bridge Dam on Deerfield River in Vermont completed. Highest hydraulic fill yet built (200 ft.).

1925 Dix River Dam in Kentucky, highest rockfill structure (275 ft.) completed.

1925 Wanaque Dam in New Jersey completed, on which both earthfill and concrete corewall materials were placed with belt conveyors, totaling 2½ miles in length.

1930 Saluda Dam in South Carolina built by semi-hydraulic fill methods to unprecedented height of 208 ft. and containing 11,000,000 cu. yd. Signs of high line of saturation appear after reservoir is filled, and a slump in downstream face results in installation of drains.

1931 Salt Springs Dam in California, highest rockfill (328 ft.) completed. Cobble Mountain Dam in Massachusetts, highest earthfill (245 ft.) also completed, by hydraulic-fill methods. Dam has large rockfill toes.

1933 New methods for engineering control of soils for rolled-fill dams developed in connection with construction of large earth dams for Los Angeles Bureau of Waterworks and Supply.

1933 A cutoff wall consisting of 31 cellular concrete caissons sunk 140 ft. to rock at site of Quabbin Dam in Massachusetts, an earth structure of rolled and hydraulically-placed fill.

1936 Further improvements in methods for design and construction of earth dams developed on Muskingum Valley flood-control work in Ohio.

1937 San Gabriel Dam No. 1 near Los Angeles, Calif., completed. Built of rock and rolled earth to a height of 375 ft., the dam set a new height record for that type of structure.

1938 A slide involving 5,000,000 cu. yd. occurs in downstream toe of Fort Peck Dam as structure nears completion. It was caused by a shearing failure in the weathered shale in the foundation. In reconstruction a berm was added along the slide area.

1939 Fort Peck Dam on upper Missouri River completed, chiefly by hydraulic fill methods. Dam is 242 ft. high, 9,000 ft. long and with material added following slide of 1938 contains 122,000,000 cu. yd. of which 2,000,000 is rock and gravel, making it largest earth dam.

1942 Mud Mountain Dam, an earth and rockfill structure near Seattle, Wash., completed to record height of 425 ft. Unusual refinements in rolled earth construction applied here including passing core material through dryer and use of tent over core during construction to control moisture content.

1942 To provide watertightness at Nantahala Dam in western North Carolina, a 260-ft. high rockfill, the usual upstream slab was replaced by an inclined core of silt protected by an upstream layer of rock. There are filter layers each side of the silt.

1948 Anderson Ranch Dam in Idaho, highest earth fill, 456 ft., completed by rolled-fill methods.

DESIGN THEORY

1874 Otto Mohr formulated the principle of virtual displacements for analysis of trusses.

1875 A series of articles on "Graphical Analysis of Roof Trusses," by Prof. Charles E. Green, in ENGINEERING NEWS introduced in the U.S. the reciprocal-diagram method of James Clerk Maxwell (18664) – the well-known Maxwell diagram for bar stress.

1876 Alberto Castigliano advanced the theorem that the partial derivative of the strain energy with respect to one of the external forces acting on a body in equilibrium gives the displacement corresponding to that force. This observation led to the development of the dummy "unit-load, least-work and virtual-work methods permitting analysis of statically indeterminate structures.

1877 Williot developed a graphical method for determination of truss deflections.

1885 H. Muller-Breslau extended the method of elastic weights to the computation of truss deflections.

1888 Deflection theory for suspension bridges published by J. Melan.

1891 Carus Wilson applied the photoelastic method to the measurement of stresses in a beam.

1892 Otto Mohr simplified the calculation of secondary stresses in trusses, which he followed in 1906 by the development of the method of successive approximations.

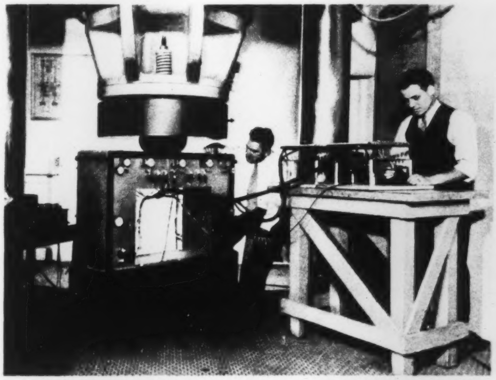
1910 S. Timoshenko developed the energy method for handling stability problems, most common in airplane design, but also of importance in structural engineering.

1915 Slope-deflection method in its modern form proposed by G. A. Maney for rigid-frame analysis. It is based on equations originally advanced by H. Manderla (1878).

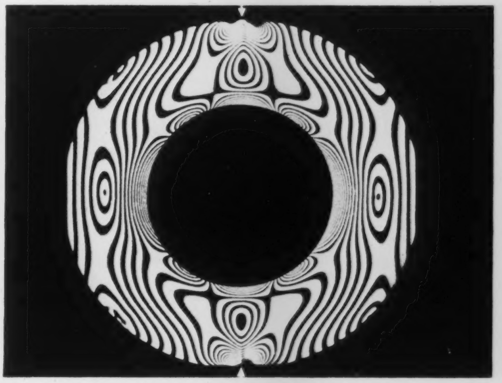
1922 George E. Beggs developed a practical mechanical device for obtaining influence lines for continuous beams. It was based on Maxwell's reciprocal-deflection theorem (1864), which infers that a deformation curve and an influence line have the same shape. In this year also, Otto Gottschalk published a description of his Continostat, which consisted essentially of a steel bar with arms designed to hold models made from steel splines in a distorted position while observations are made of the deformations.

1929 Method of successive approximations introduced in its modern form by Hardy Cross. Moment distribution by this procedure greatly simplified the analysis of indeterminate structures.

1940 J. A. Van den Broek's papers on "Theory of Limit Design" provoked wide-spread and continuing interest in this subject. As data becomes available, design specifications are being changed to conform.



Stress and strain determinations, made with electric wire resistance gages on a concrete rigid-frame model at the Bureau of Reclamation Denver laboratory, provide design data for modern structures. The wire resistance gage was introduced in 1939.



Photoelastic stress patterns, like the one for the above ring, enable stresses to be determined by passing polarized light through a small transparent model. The method dates back to 1891, when Wilson applied it to a beam.

HIGHWAYS

1887 Numerous local organizations of wheelmen consolidated into the League of American Wheelmen. It started the first good-roads movement.

1891 New Jersey is first state to authorize state aid for county roads.

1892 First portland-cement concrete pavement built, in Bellefontaine, Ohio.

1893 Congress sets up the Office of Road Inquiry (which became the Bureau of Public Roads in 1918) and instructs it to report on best methods of road construction, maintenance and operation.

1893 Duryea successfully operates the first automobile in the U.S., and Ford builds his first automobile.

1893 First brick pavement laid on a road outside corporate limits. Cuyahoga County, Ohio, lays 8-ft. wide vitrified brick pavement on South Woodland Road and Wooster Pike.

1897 Object-lesson road built by the Office of Road Inquiry at New Brunswick, N. J.

Reconstruction of main highways to modern standards accounts for a large part of the highway work in recent years. This is on relocated U. S. 99 in northern California.

1898 Los Angeles County oils six miles of road to lay the dust, starting a movement that spread rapidly.

1900 Road materials laboratory established by the Office of Road Inquiry.

1901 Fred J. Warren lays first bituminous concrete pavement in Pawtucket, R. I. under his patent system.

1902 American Road Builders Association and American Automobile Association organized.

1902 Use of sand-clay type of road promoted by Office of Road Inquiry, resulting in general use of a method known in ancient times.

1905 Bituminous concrete used on rural roads in Rhode Island.

1905 Experiments to determine utility of crude Texas oil as a binder for earth and macadam roads started in Madison County, Tenn.

1908 First known use of superelevation on Long Island Parkway, which was used for Vanderbilt Cup Races.

1909 Wayne County, Mich., lays 18 ft. wide concrete pavement on Woodward Avenue Road. First concrete pavement outside corporate limits, it was 6½-in. thick, built in two layers.

1912 Thickened-edge cross-section adopted for concrete pavements in base construction in California.

1912 Federal government authorized appropriation of $500,000 to pay one third of cost of roads over which mails are carried.

1914 American Association of State Highway Officials organized.

1916 As result of inquiry begun in 1912, Congress passes a more comprehensive federal-aid highway act, which set up the formula for apportioning funds to states that is still used, in slightly modified form.

1919 Motor-truck impact studies initiated by the Bureau of Public Roads. Result of these tests soon led to substitution of pneumatic for solid tires on trucks.

1919 Formulas for design of concrete pavements proposed by A. T. Goldbeck as a result of studies of pressures in subgrade under such pavements.

1920 Construction of Bates test road begun by Illinois Highway Department.

1920 Highway Research Board established as a unit of the National Research Council.

1921 New federal-aid highway act requires each state to designate a connected system of federal-aid highways not to exceed 7 percent of its rural roads. States required to adequately maintain federal-aid roads.

1921 Development of standard highway bridge specifications begun by American Association of State Highway Officials. These standards were published in 1931.

1921 Effect of moisture on highway subgrades and methods of soil testing published by Bureau of Public Roads.

1921 Test road built at Pittsburg, Calif. to study plain and reinforced concrete pavement.

1922 Cement mixed with soil on road surface in Iowa to determine its value as a stabilizing material. This was first soil-cement road.

1924 Study of soils in relation to highway construction as a full scale research project begun by Bureau of Public Roads.

1925 Joint Board on Interstate Highways, appointed at request of American Association of State Highway Officials, submits a system of U. S. Highways and a plan for uniform signs and markers. Sign manual issued in 1927.

1925 Westergaard theory of concrete pavement design developed as result of investigation sponsored by the Bureau of Public Roads.

1928 Emulsified asphalt stabilization first used on Beck Road in Alameda County, Calif.

1931 Gross-load formula for use in regulating weights of vehicles proposed to Highway Research Board by A. L. Gemeny.

1932 Report on design of street and highway intersections by L. S. Tuttle and E. H. Holmes published. This marked beginning of studies of geometric design.

1933 National Industrial Recovery Act allocates $400,000,000 to highway work; 50 percent to the federal-aid system outside cities, 25 percent to highways through cities and 25 percent to feeder roads. The normal requirement that states match the federal aid on a 50-50 basis lifted temporarily.

1934 Congress authorized the states to use up to 1½ percent of their allotments for highway planning surveys, thus inaugurating nation-wide advance planning for highways. This act restored the 50-50 matching requirement beginning in the fiscal year 1936.

1936 First urban expressway opened at St. Louis.

1936 Construction of Inter-American Highway begun.

1937 First law limiting access of abutting property owners to a "free-way" passed in Rhode Island. Similar law enacted in New York.

1939 Public Roads Administration submits to Congress its report "Toll Roads and Free Roads," which found no need for toll roads and opposed their construction. An interregional highway system also proposed.

Highways of unprecedented size and cost are now being built to serve large centers of population adequately. This is the controlled-access freeway at Dallas, Texas.

1940 Pennsylvania Turnpike, first toll road to be built in modern times, opened to traffic.

1940 Scaling of concrete pavements reduced by addition of air-entraining agent to mix used in test road at Universal Atlas Cement Co. plant at Hudson, N. Y.

1941 Public Roads Administration reports to President on defense highways. Congress, as a defense measure, authorizes $20,000,000 to aid Central American countries in completing Inter-American Highway.

1942 Work started on Alaska Highway.

1944 National Interregional Highway Commission proposes a National System of Interstate Highways of 33,920 miles. Standards for the system were set by the AASHO in 1945, and in 1947 the highways to be included were approved by the states and the Bureau of Public Roads.

1944 Postwar Highway Act approved. $500,000,000 authorized for expenditure in first three post-war years, of which $125,000,000 was to be spent on highways through cities, $150,000,000 on secondary roads, and remainder on the federal-aid primary system.

1949 A report on highway needs for national defense submitted to Congress by the Bureau of Public Roads.

AMONG MEMORABLE EVENTS THESE WERE SIGNIFICANT

CONSTRUCTION MACHINERY

1875 Rocker-type dump cars gave railroad contractors one more tool for the embryonic mechanization that characterized construction's final decades of high-pressure railroad building.

1875 Continuous mixer faintly encouraged concrete construction, which was to become important 20 years later.

1875 Single-acting steam pilehammer speeded up foundation work, allowing faster driving with lighter rigs.

1877 Wheeled scrapers, several dozen of them, were built by an Iowa contractor on a Burlington Railroad spur. This tool, as an improvement over the slip scraper, contributed to progress far afield from railroading in the years that followed.

1878 Road grader, a steel blade hung beneath a wooden wagon, also would become widely useful, especially when highway work mushroomed.

1881 Separate engines for boom, hoist and crowd on steam shovels, began an era of advances that were spurred by great earthmoving projects like the de Lesseps Panama canal.

1883 Clamshell bucket, with a quarter-century of dredge service to its credit, first modified for dry-material handling.

1883 The elevating grader, soon powered by 16-24 head of mules, took a lot of waste motion and muscle-power out of open-country railroad excavation.

1884 Automatic steel-rotation incorporated in the old cam-and-piston rock drill.

1885 Steam tractor, with broad iron wheels foreshadowed the doom of the horse and mule.

1890 Hoisting engine powered by electricity – one of the earliest answers to the demand for compact power units, and one of several improvements that enabled fast material handling in tall-building construction.

1891 Steam roller made smooth street surfaces possible.

1892 Bottom-dump wagon – the partner that the elevating grader had been waiting for – took the labor out of dumping (shoveling out or dismantling the wagon box).

1893 Pressure-ignition internal combustion engine patented by Rudolph Diesel. The next half-century would see the diesel become the contractor's most powerful ally.

1893 Double-acting steam hammer first marketed.

1894 Electric power put in a Montana placer dredge.

1895 Full swinging shovels built for working ore piles.

1895 Belt conveyors handled dirt on the Chicago drainage canal, one of the first great jobs on which machines were coordinated into an effective construction plant.

1896 Hammer-type rock drill invented. Lighter than previous drills, this tool gained quick acceptance.

1897 Pneumatic riveting hammer helped in the demand for quicker steel-erection methods.

1898 Diesel engine built by U. S. patentee, Adolphus Busch, and put to work in Mr. Busch's St. Louis brewery.

1899 Portable air compressor widened the versatility of compressed air power.

1899 Steel-drum tilting concrete mixer did its part for concrete construction during its fastest stage of growth.

1903 Full-revolving wooden-boomed excavator on Hennepin Canal rigged with drag bucket, making this machine the forerunner of the dragline.

1903 Friction-clutch drive enabled use of one motor (electric) on shovels.

1904 Crawler tracks, called "platform wheels," were put on a steam tractor. Developed for farm use, it was adopted for construction.

1905 The first paver came into existence when a manufacturer applied power to the wheels of a concrete mixer.

1905 Ladder-type trencher entered a field that previously had been the domain of wheel-type machines.

1905 The gasoline engine joined forces with construction. In this year a hoisting rig was powered by gasoline.

1906 Mechanical dumping device placed on trucks.

1906 Steel forms produced for concrete work.

1907 Power-loading skip on concrete mixer allowed a full batch to be charged at once.

1907 Sheepsfoot roller used on West Coast road work.

1908 Crawler tractor powered by gasoline. Thirty-seven were used on the Los Angeles aqueduct.

1908 Crude concrete-chuting plants began to appear on building jobs.

1909 Compressed-air machine for "slugging" concrete through pipes against gravity was the first concrete pump.

1910 Crusher and elevator mounted on a four-wheel truck; the first of the portable crushing and screening plant ideas.

1911 Crawlers put on a crane to improve flotation.

1912 Lightweight steel forms developed for sidewalks, curbs and roads.

1912 Jackhammer, a one-man rock drill, developed.

1913 Walking principle applied to dragline locomotion.

1915 Bulldozer, mule-powered, first manufactured. Had been built previously by individual contractors.

1916 Transit mixer idea began to develop.

1918 Truck cranes built for American Expeditionary Force.

1918 Finishing machines speeded concrete paving.

1919 Crawlers on pavers placed lower unit load on subgrade, thereby reducing non-uniform compaction.

1919 Bituminous distributor helped improve the quality and uniformity of penetration roads and streets.

1920 Batching plants for concrete aggregates eliminated a large amount of hand-shovel and wheelbarrow work.

1922 All-welded tractor-drawn scrapers, with 6-yd. heaped capacity, had electric bowl-tilting power.

1923 A complete portable crushing and screening plant was placed on the market.

1923 Bulldozer put on tractor (manual hoisting).

1923 Heavy-duty trailers made transportation of large equipment more flexible.

1924 Electric handsaws made power cutting available anywhere on the job.

1924 Diesel power put into excavators. This marked the entry of the diesel into ever-increasing favor among users and makers of heavier equipment types.

1925 Hydraulically-controlled bulldozer introduced.

1926 Booster steering on trucks paved the way for larger haulage units.

1926 Sequence-control invented for pavers. Operation of one lever raised skip, measured water, lowered skip and timed mix. Helped assure uniformity in pavement concrete.

1928 Concrete-chuting plants began descent to oblivion.

1928 Cable-control applied to bulldozers and scrapers.

1929 Road mix machine was the first of a series of tools that improved the competitive position of bituminous highway construction.

1930 Bulk-cement handling equipment introduced.

1930 Bituminous finisher used on a Missouri street job.

1931 Detachable drill bit eliminated transporting long steel for re-sharpening.

1931 Diesel power became available in tractors and graders. Decrease engine weight-horsepower ratio made this new application possible.

1932 Bituminous paver placed on market.

1932 Concrete-pumping machinery developed.

1932 Concrete spreaders came into general use.

1932 Dual-drum paver, 27E, almost doubled the day's concrete pavement output.

1932 Rubber tires put on scrapers.

1933 Full-carrying scraper introduced, with apron that kept 12-yd. load from spilling. All previous scrapers, having no apron, were known as "semi-drags." This efficient tool came at a fortunate time for, with advances in the science of soil mechanics and with big government public works programs, great earth structures soon were to be built.

1934 Off-the-highway dump trucks and wagons first built. Their big rubber tires enabled them to operate in soft ground that would bog conventional units.

1935 Internal vibrators for concrete patented in U. S.

1936 Ballastable roller. This was one of several developments in response to soil mechanicians' demand for controlled earth compaction in earth structures of the era.

1937 Hydraulic control eased the shovel operator's job.

1938 Another high-speed earthmoving event was the rubber-tired self-propelled scraper. This unit with its 2-wheel tractor coupled to its 2-wheel carrying scraper was a highly maneuverable addition to the earthmover's tool box.

1940 Unprecedented 9.6 mile belt conveyor brought aggregate to Shasta Dam.

1941 Four-wheel tractor (rubber-tired) re-entered the construction field.

1942 An important World War II development was the Services' almost universal adoption of power drive on all wheels of motorized vehicles.

1943 Hydraulic coupling put in heavy tractor power train.

1945 Self-powered road-mix machine dug to subgrade, pugmilled the earth with added stabilizing agents and spread the mix evenly on the subgrade.

1947 Rubber-tired bulldozer first placed on the market.

1948 The last word in compaction equipment was a heavy vibrating roller with pneumatic tires.

1948 Vibration applied to cutting edge of an excavating tool, in this case a mechanical subgrader for pavements.

1949 Power applied to all four loaded wheels of a tractor-semi trailer scraper (also on a bottom-dump wagon).

RIVER CONTROL

1874 Board of engineers appointed to survey the mouth of the Mississippi River to determine best method for obtaining and maintaining sufficient depth for commercial navigation.

1876 James B. Eads proposes construction of cutoffs along lower Mississippi River to improve the navigability of the river, contrary to established practice of preventing cutoffs.

1878 Framed willow mattresses used for the first time to protect banks of the Mississippi in Memphis District from erosion. This was start of extensive bank revetment work. In 1896 willow facine mattresses were adopted as standard.

1879 Mississippi River Commission created by Congress to coordinate improvement of the river below Cairo, Ill.

1889 A convention between Mexico and the United States provides for control of border waters and sets up the International Boundary Commission.

1893 California Debris Commission established by Congress to control hydraulic dredging in the gold fields to prevent blocking of rivers and damage to bottom lands.

1907 Inland Waterways Commission appointed by President Theodore Roosevelt to report on a comprehensive plan for improvement and control of the river systems of the United States, including flood protection. Its report, submitted the following year, recommended that all future plans for river work take into account purification of the streams, flood control, power and irrigation requirements.

1909 International Joint Commission set up by treaty between United States and Great Britain to control waters along and across the boundary between United States and Canada.

1913 First detailed inventory of water resources of any state undertaken in Pennsylvania under legislative act. Ten-volume report published in 1917.

1914 Following serious floods in Miami River valley in Ohio, state legislature passes "Conservancy Act of Ohio" authorizing creation of conservancy districts to build flood-control works and assess costs on benefited regions.

1914 First monolithic concrete revetments, 125 x 50 ft., launched from casting barges in Memphis District on Mississippi River. Larger and more heavily reinforced mats were laid until about 1924 when they were abandoned due to cost and difficulty in handling.

1915 Articulated concrete revetment laid by Vicksburg District on Mississippi River. Improved types were developed in later years and are still in use.

1917 Congress passes act assuming responsibility for control of floods on lower Mississippi River and Sacramento River; local agencies to pay at least half the cost.

1920 First comprehensive study of a river system in which development of water power and the control of floods was made integral with plans for navigation begun by the Corps of Engineers in the Tennessee River basin.

1927 Congress authorizes comprehensive studies of principal river basins, resulting in the well-known "308 Reports" of the Corps of Engineers on all main river systems.

1927 Major flood occurs on the Mississippi River.

1928 Congress approves new flood-control plan for the Mississippi River, known as the Jadwin plan. It includes floodways for use at times of extreme high water instead of depending solely on levees. Construction of the Waterways Experiment Station at Vicksburg also authorized.

1932 First asphalt-mat revetment fabricated and laid in New Orleans District on the Mississippi.

1933 First artificial cutoff opened on the lower Mississippi River, thus reversing a policy adopted in 1879.

1933 Construction of Fort Peck Dam begun, first major multiple-purpose reservoir on the Missouri River.

1933 Act setting up the Tennessee Valley Authority passed by Congress.

1936 As a result of widespread flood damage, Congress passes flood-control act declaring protection of life and property against destruction by floods on large rivers to be a responsibility of the federal government. Heretofore all federal flood-control work, except on the Mississippi and Sacramento rivers, had been done in the name of navigation.

1938 New flood-control act passed eliminating features of 1936 act that had delayed start of many projects. Federal Power Commission given authority over power developed at flood-control dams.

1940 Federal government's power to undertake flood-control work affirmed by the U. S. Supreme Court.

1944 United States and Mexico sign treaty for control of the waters of the Colorado, Tijuana and Rio Grande.

1944 Unified development of the Missouri River basin by the Corps of Engineers and Bureau of Reclamation authorized by Congress under flood-control act.

IRRIGATION

1877 First recognition by federal government of importance of irrigation of arid lands was passage of Desert Land Act authorizing sale of 640 acres at $1.25 an acre to anyone who would irrigate it in 3 years.

1879 Report by John W. Powell on "Lands of the Arid Region of the United States" issued by the newly-founded U. S. Geological Survey.

1887 Passage by California of Wright Irrigation District Act. Forerunner of similar acts in other states which brought vast acreages under irrigation on a sound amortizable basis.

1893 First commercial-scale pumped irrigation project built by Yuma Water and Light Co.

1894 Carey Act cedes public lands to states for development by private capital. Larger area developed under this act than under any other legislation enacted either by the states or the federal government.

1902 Reclamation Act signed by President Theodore Roosevelt, inaugurating program under which 5,000,000 acres have been irrigated and 2,500,000 kw. of power installed. Prior to Reclamation Act about 9,000,000 acres had been brought under irrigation.

1903 Salt River project in Arizona begun, the first under the Reclamation Act, although Truckee-Carson or Newlands Project in Nevada started about same time was in operation six years before Salt River.

1905 First desilting works built as an appurtenance to Laguna Dam on Yuma project to remove heavier portion of Colorado River silt and thus reduce canal maintenance.

1906 Development of the deep-well turbine pump permitted more efficient use of ground water for irrigation.

1906 Power Act passed by Congress authorizes Secretary of Interior to grant ten-year rights to surplus power on irrigation projects.

1907 Bureau of Reclamation established in the Department of the Interior.

1908 Drainage first recognized as essential adjunct to irrigation by building drainage canals on Minidoka project in Idaho. Also first large pumping plant completed on this project; total lift, 90 ft.

1911 Roosevelt Dam on Salt River dedicated, first of the Reclamation Service.

1915 Arrowrock Dam, then the world's highest (354 ft.) completed on Boise River in Idaho.

1922 Colorado River Compact signed, opening way for construction of Hoover and other dams on Colorado River.

1928 Boulder Canyon Project Act passed. Authorized the first large scale multi-purpose project, including construction of 726-ft. Hoover Dam (begun in 1931, completed in 1935) and All-American Canal. Ultimate Hoover hydro-power to be 1,323,500 kva.

1931 Plans for Central Valley Project in California presented to that state's legislature after 10 years' study.

1933 Construction begun at Grand Coulee Dam, key structure of the Columbia Basin Project; water for 1 million acres; hydro power of 2 million kw.

1933 Tables prepared to solve any critical-depth flow problem for rectangular, trapezoidal or triangular shapes enabled designer to fix bottom width and side slope so that water surface in a canal does not fluctuate greatly with changes in flow conditions.

1934 Giant desilting basins equipped with rotary scrapers begun at Imperial Dam to remove Colorado River silt from water for All-American Canal.

1937 Large-scale canal lining machines used for first time on Colorado River aqueduct.

1939 Reclamation Project Act passed liberalizing contract arrangements with water users.

1944 Flood Control Act of 1944 provides for unified development of the Missouri River basin through cooperative effort of the Bureau of Reclamation and Corps of Engineers.

1944 Shasta Dam completed. Key feature of California Central Valley Project, which will move irrigation water a record distance of 500 miles.

1946 Bureau of Reclamation inaugurates study of low-cost lining for irrigation canals in an effort to reduce lost water.

1947 Completion of 13-mile Continental Divide tunnel of Colorado–Big Thompson project, bored to bring Pacific slope water to 600,000 acres on the plains north of Denver.

1948 Upper Colorado River Basin Compact signed, apportioning the Colorado River water allocated to the Upper Basin among the signatory states.

TUNNELS

1874 Hoosac tunnel, in western Massachusetts, completed. Power drills and dynamite were adopted for the first time on this 4¾-mi. rail tunnel job.

1878 Sutro tunnel work ended. Intended to drain hot ground water from mines of Nevada's Comstock Lode, this 4-mi. job finished just as the ore became unprofitable.

1879 Hudson and Manhattan tunnel work begun at Hoboken, N. J. Light iron liner plates used. On this, the first compressed-air job in the world, the builders tried to drive without a shield, but experienced a blow-out that cost twenty lives. Work resumed with a pilot bore, but stopped again in 1882, after 1600 ft. of progress.

1882 Sewer tunnel completed in rock under Dorchester Bay, Boston.

1885 Second Croton aqueduct to New York begun. With its 40 shafts and 80 headings it was a useful drilling school.

1888 Shield and cast-iron liner plates first used on a compressed-air job in America, on 21-ft. diameter international railroad tunnel under St. Clair River at Sarnia, Ont.

1888 First tunnel through the Cascade range in Washington completed by Northern Pacific RR. (2 mi.). The Great Northern built its original Cascade tunnel a few years later.

1889 Work resumed in first Hudson and Manhattan tunnel, with shield and air, (suspended again in 1891, resumed in 1902 and opened to traffic in 1908).

1891 Baltimore Belt Railroad double-track tunnel, 8,000 ft. long, built in soft ground with a top heading and two side drifts; notable for amount of timbering used to hold earth.

1899 Chicago's Northeast intake tunnel completed under Lake Michigan, connecting the city's water system with an intake crib 2 miles out in the lake. This was the seventh of a series (of similar tunnels) begun in 1864. Milwaukee and Cleveland also built lake intake tunnels during that period.

1904 Mile-long East Boston subway tunnel under Boston harbor opened for traffic. Ceiling ventilation duct drew tunnel air each way from mid-point.

1904 A 400-ft. long Harlem River tunnel in New York built by sinking sections within cofferdam.

1906 Trench method – lowering tunnel sections into a dredged trench – first used on Detroit River railroad tunnel.

1908 New York Subway tunnel put into service between the Battery and Brooklyn. This was the first tunnel built in the East River's difficult mixed ground (rock, sand, clay).

1909 Gunnison tunnel, Colorado, holed through. This 6-mile bore was a pioneer U. S. Reclamation Service tunnel, for carrying irrigation water.

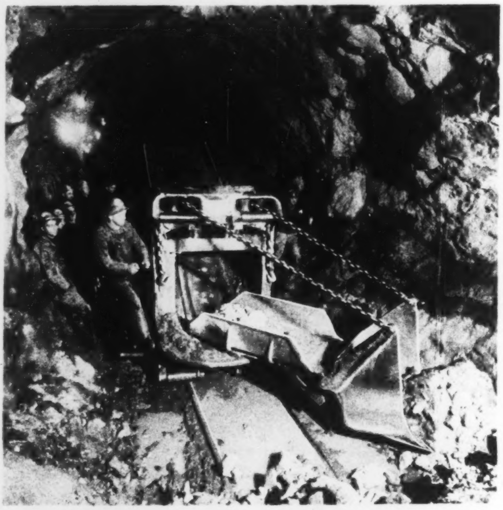
1910 The oldest tunnel under the Chicago River, at Washington St., lowered to allow passage of larger craft. Tunnel had been built inside cofferdam, in 1866-69.

1916 Rogers Pass tunnel holed through, to supersede Hoosac tunnel as the longest rail tunnel in America. This double-track tube in the Rockies of British Columbia was driven from 16 headings, accessible by cross-cuts from parallel pioneer bores. (Length 5.02 mi.)

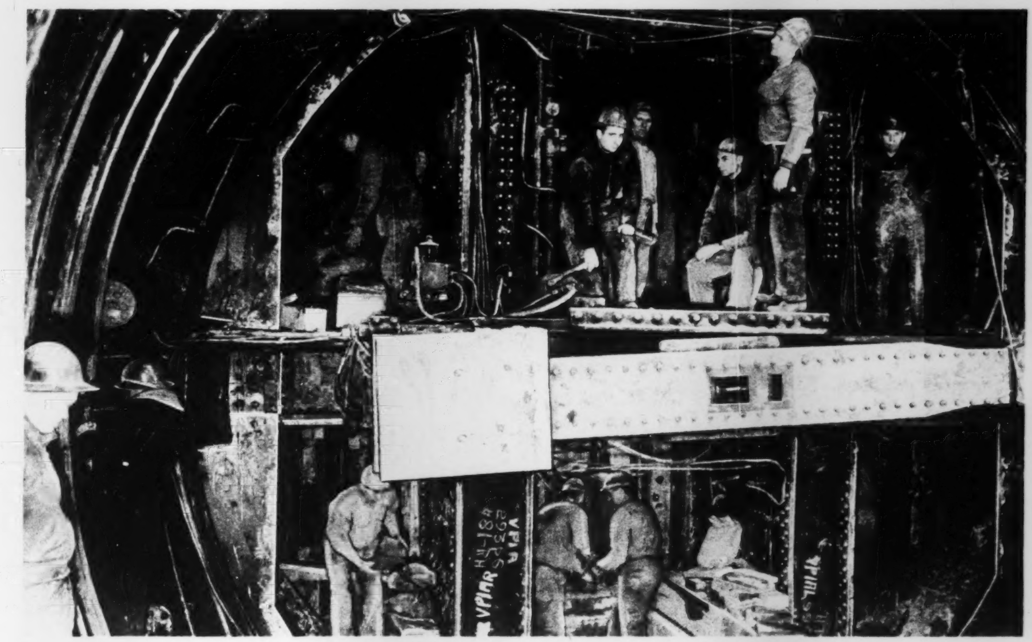
1923 Shandaken tunnel, part of New York's Catskill aqueduct, holed through to become the longest continuous tunnel (18.1 miles).

1924 Vehicular-tunnel ventilation became a popular problem when, during a traffic jam in Pittsburgh's new Liberty tunnels, groggy motorists abandoned their cars in panic.

1927 Holland tunnel, between New York and Jersey City, completed. Significant because problem of ventilating long vehicular tunnels had been licked by mechanical means, and because the tunnel became one of the most profitable toll structures in the world. (Length 8,555 ft.)



ROCK TUNNELING has been speeded by many mechanical aids. Here a mucking machine digs rock that has been blasted from the face. Rock travels on belt, to discharge into muck cars.



SUBAQUEOUS TUNNELING in soft ground became feasible when the shield was developed. This modern type pushes forward with hydraulic jacks that act against previously-placed tube rings.

1927 Moffat Tunnel completed in Colorado Rockies, to become, briefly, America's longest rail tunnel (6.11 mi.)

1928 Cascade tunnel, 7.79 miles long, broke the Moffat record. This Great Northern bore in Washington replaced the higher, shorter tunnel built by that railroad in the Nineties.

1928 Vehicular tunnel built with sunken tube sections under estuary at Oakland, Calif.

1930 Excavation completed for Detroit River vehicular tunnel. Pressed steel liner plates first used, in shield-driven approaches. River portion built by trench method.

1932 Boulder Dam diversion tunnels, 56 ft. diameter, completed well ahead of schedule with aid of truck jumbos that worked 75 percent of the face area. (Total length 3 mi.)

1934 East Boston vehicular tunnel opened. Belt conveyors carried muck away from the face and through air locks.

1936 Yerba Buena tunnel, part of San Francisco Bay Bridge, became world's largest tunnel: Inside width, 65½ ft.; height, 48¼ ft. (Length 540 ft.)

1939 San Jacinto tunnel completed after a long battle against water in seamy, faulted rock, to become the thirty-eighth and last tunnel link in California's Colorado River aqueduct. Inflow totaled as much as 40,000 gpm.

1940 Pennsylvania Turnpike opened. Six of its seven tunnels were modifications of tunnels started for the abandoned South Penn Railroad.

1940 Queens-Midtown tunnel opened in New York. Large-size bores (two) plus the East River's mixed ground conditions (and a bad fire in compressed air) made this one of the most difficult subaqueous jobs in history.

1940 Work began on Brooklyn-Battery tunnel, New York, to be completed 1950. (Length 9,117 ft.)

1941 Carlton tunnel completed. This 6-mi. hole drains deep mine workings in Colorado's Cripple Creek district. Single-heading record, 1,879 ft. in a month, made here.

1943 Chicago's first subway put into operation. Both shield and open-face hand mining had been employed in the large compressed-air bores.

1944 Delaware aqueduct, an unprecedented 85-mile rock tunnel, placed in service to bring water to New York. Work had been conducted from 31 shafts, under 12 contracts.

1947 First irrigation water passed through 13.1-mile Alva B. Adams tunnel under Continental Divide in Colorado. Longest bore ever driven from only two headings.

1949 Burning of 4,400-gal. truckload of carbon disulphide in Holland Tunnel proved tunnel's design, both of structure and of ventilating system; despite heavy damage to lining cast-iron tube remained sound, and 60 persons escaped without suffocation.

HISTORY

WEEK BY WEEK

ENGINEERING NEWS-RECORD'S ROLE IN BUILDING A GREATER AMERICA

"I shall be content if those shall pronounce my history useful who desire to give a view of events as they really happened."—Thucydides

THE spring of 1874 was a notable one in the annals of civil engineering. At New York the Brooklyn tower of the great East River suspension bridge was rising above the water-front buildings under the watchful eye of Washington A. Roebling, and the New York & Harlem Railroad's "sunken tracks" were being built through 4th Ave. To the north, the Hoosac Tunnel, longest yet attempted in this country, was being driven successfully in western Massachusetts.

At Chicago, another tunnel that was to bring pure water to the city had been completed from the shore of Lake Michigan to an intake crib two miles out in the lake; and down at St. Louis, James B. Eads was striving to complete his epoch-making steel arch bridge across the Mississippi River in time for an official opening on July 4. Farther west the rough and tough railroad gangs of the Kansas Pacific and the Santa Fe were laying track and fighting Comanches in a race to capture Raton Pass, gateway to a Southwest Empire, and a second route to the Pacific Coast. The wobbly ribbon of rails joined by a golden spike in Utah five years earlier already provided the Union Pacific and the Central Pacific with a transcontinental line of sorts.

In that same spring of 1874 there appeared in Chicago a small 16-page journal called *The Engineer and Surveyor.* It was published by George H. Frost, a civil engineer and surveyor, "to fill the vacancy now existing in the engineering literature of the country."

The Engineer and Surveyor was the first seed from which a richly foliaged plant to be known as *Engineering News-Record* grew. A hardy perennial, it was also bifurcated, its other stem arising about four years later when Henry C. Meyer, a public-spirited dealer in plumbing supplies, brought out another 16-page magazine in New York which he called *The Plumber and Sanitary Engineer.*

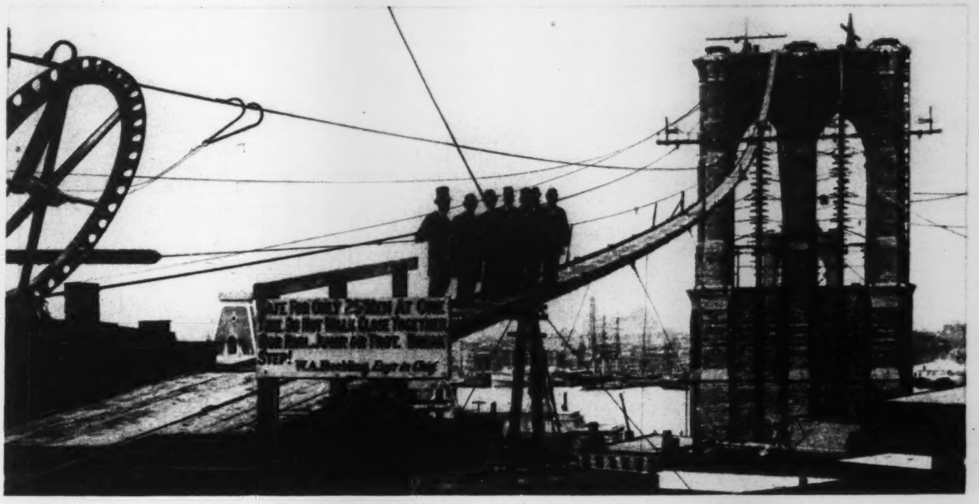
The Engineer and Surveyor became *Engineering News* in 1875 when weekly publication began. *The Plumber and Sanitary Engineer,* after several changes in name, settled on *Engineering Record* in 1890. Battlelines thus were drawn for a great competition in technical journalism, which was in no wise diminished when James H. McGraw bought the *Record* in 1902, nor later in 1911 when John A. Hill purchased the *News.*

Like Frost and Meyer, however, McGraw and Hill were men of vision and high principles who regarded technical journalism as a means of service to the reader. To them, magazines were vehicles of education and mediums for advertising, not tools and promotional devices for sellers of merchandise. The competition between the *News* and the *Record,* therefore, never degenerated into personal feuds or factional fights. Each magazine sought to serve its readers better and faster than the other by more accurate and more complete coverage of news and technical developments. When merger of the two publications occurred in 1917, therefore, their policies were fused without difficulty, their staffs combined with a minimum of readjustment.

The pages of the two journals brought together by the merger of 1917, together with those of *Engineering News-Record,* comprise the most authentic and complete history of civil engineering and construction in America that has ever been written. The result could hardly be otherwise, with a new chapter being brought out each week for 75 years.

The causes that the editors have championed have more often than not been those that proved to be constructive. Even those that were mistaken have frequently been beneficial in stimulating thought and action that advanced the art. In any event, the magazine has been so much a part of the life and times of civil engineering in America for the past three-quarters of a century that a review of some of the great events that have been reported in its pages and of some of the significant movements in which it was involved has a logical place in this issue. So, back to the beginning—

The year 1874 was not a propitious one in which to launch a new publishing venture that was to depend on civil engineers for its support—as Frost was to


AFE FOR ONLY 25 MEN AT ONE
TIME. DO NOT WALK CLOSE TOGETHER
NOR RUN, JUMP OR TROT. BREAK
STEP!
W.A.Roebling Engr in Chief

WHEN CABLE SPINNING was in progress on the Brooklyn Bridge, editor Frost made the hazardous trip to the top of one of the towers to get a first-hand description of the work.

learn before the year was out. By the end of 1874, the full effect of the panic of 1872 began to be felt in the construction field. Railroad building, which then was providing work for thousands of engineers and contractors, fell off sharply, declining from over 7,000 miles in 1872 to 1,600 miles in 1875. Other types of construction were similarly affected.

By the spring of 1875, however, an upturn in business had begun. The U. S. was growing far too fast for a financial panic to check its expansion for any length of time. Bankrupt railroads were being reorganized or combined with others, and more new construction was being planned. Over 2,500 miles of new line were built that year. Things began to look up for the fledgling magazine and for its readers.

An early appraisal

Editor Frost mirrored his feelings in a front page statement in the first issue of 1875. "The year just closed," he wrote, "has been a season of hard times for American engineers and surveyors. . . . But civil engineers are familiar with intervals of 'nothing to do'; they are not infrequently obliged to suffer the loss of their earnings by the failure or dishonesty of the individuals or corporations employing them; they are often exposed to sickness and disease, and are otherwise subjected to the ordinary ills of life; they are usually, however, men of more than average intelligence, and possessed of large practical ability; apt to devise and prompt to execute expedients to meet every emergency. We believe, therefore, that the great body of the engineering profession of the country are, at the present writing, better prepared to await, with a contented philosophy, the return of better days, than are our debt-burdened merchants, manufacturers and speculators."

Frost's comment ended on a note of optimism that was fully justified by subsequent events. "Engineering," he said, "is the science of civilization and must ever be in the van. The time is not far distant when the services of civil engineers will be greatly in demand. And while English, French and German engineers will largely control certain territories, yet to American talent there is a vast field open, and it behooves them to be ready to take advantage of each opportunity as it is presented."

Fitting action to precept, Frost engaged Prof. Charles E. Greene of the University of Michigan to write articles regularly on how to make graphic analyses of roof trusses. He also obtained comment on current engineering subjects from such prominent engineers as Professors Charles A. Smith and Mansfield Merriman, W. Milnor Roberts (president of the ASCE in 1879), and Clemens Herschel. Another useful contribution was a series of articles by Rudolph Hering discussing all the formulas then in current use for determining the safe bearing capacity of wooden piles.

It was in this same period also that the journal inaugurated what since has become a regular practice, first-hand reporting of accidents of civil engineering significance. Frost, returning from a meeting of the ASCE in Boston, was in New York when the fall of a strand from a cable of the Brooklyn Bridge, then under construction, killed two workmen.

Going to the bridge early the following morning he was given full details by C. H. Paine, the engineer in charge, who took him to the top of one tower where he made sketches of the devices used in positioning the strands. These sketches were reproduced in Frost's report of the accident in the next following issues of *Engineering News*. It was information that the readers could not have obtained from any other source.

Tenement house reform

In the meantime, *The Plumber and Sanitary Engineer*, later to be the *Engineering Record*, had started publication. Marking a great need for improving the unsanitary condition of New York slum dwellers, the journal, scarcely a year old, started a competition in 1878 for the best design for a tenement house to be built on a standard city lot of 25x100 ft. It put up a modest prize and got some well known architects and public spirited citizens to serve as judges. Over 200 plans were received and publicly exhibited, receiving much newspaper publicity. That in turn resulted in meetings to discuss tenement house reform, out of which grew the Sanitary Reform Society, which sponsored the tenement house act of 1879.

A similar piece of journalistic initiative the same year involved publication of an article "Requirements for the Drainage of a House," a summary of Mr. Meyer's findings as a result of earlier studies of the defects of plumbing systems. Subsequently, substantially the same rules were prescribed by the boards of health of Springfield, Mass., New York and Brooklyn, and at a still later date they became the basis for the New York plumbing law, passed in 1881.

News of engineering for engineers

What were some of the other events that engineers were now able to learn about for the first time through magazines directed to their interests and written in their language?

One, for example, in June, 1875, was that a contract had been let to the American Bridge Co. for the Point Bridge at Pittsburgh, involving a new departure in suspension bridge design, in that the cables were to consist of stiffened chains of wrought-iron links.

In August, 1875, the News carried a note which said, "Columbus, Ohio, is paving its Main Street with patent materials which form a smooth and hard surface. The street is first covered with broken rock and leveled up with finely broken stone and sand upon which the composition is poured, then rolled."

At about the same time it reported that "The company organized some time ago under the name of the Hudson River Suspension Bridge and New England Railway Company is again bringing to public notice the long proposed plan of spanning the Hudson River at New York with a railway bridge." Although this one did not materialize, the magazine was able to report shortly thereafter the letting of contracts for a bridge over the Hudson at Poughkeepsie.

In the Oct. 28, 1876 issue appeared two pages of advertisements on the steel cable wire for the East River suspension bridge. Signed by W. A. Roebling, the call said, "Sealed proposals will be received by the trustees of the New York and Brooklyn Bridge up to the first day of December, 1876 for the manufacture and delivery in Brooklyn, N. Y., of 3,400 net tons of steel cable wire for the East River suspension bridge. The general character of the wire is as follows: It must be made of steel, it must be hardened and tempered and, lastly, it must be galvanized."

Bridge and tunnel accidents

The first major railroad accident involving an iron bridge occurred at Ashtabula, Ohio, Dec. 29, 1876, during a heavy snow storm. A double-track deck bridge of 157-ft. span (a Howe truss, 12-ft. deep) collapsed under a passenger train, killing 92 passengers and crew. Newspapers of the day were filled with the lurid accounts that still are common to reports of such accidents today. The News, however, undertook to give its readers all available details as to the structure itself and all engineering facts that could be garnered from official reports, thus rendering a distinctly new service for engineers of the country. Moreover it discussed at length the need for better supervision of designs for such structures and for better inspection.

The practice of on-the-scene reporting was inaugurated early. One of the first instances was a trip into one of the air locks of the heading being advanced from the New Jersey pier head line for the Hudson River tunnel in 1880. Mr. Frost was invited by "Engineer Brush" to inspect the work. On entering the air lock, according to Frost's account, "the manager of the machine gave the wheel a turn and the torture began. It started a noise sounding like the escape of steam from a steamboat's pipe. Another turn, and the sound was as of two steamboats' pipes. Here the manager was kindly content for a few minutes to cease operations. The noise continued just the same, however, and we began to feel a choking sensation in the throat and a strange ringing in both ears."

The result of this trip to the air lock was a detailed description of the tunnel work, with a large sectional drawing. But before it could be published disaster overtook the project. An undiscovered air leak over the passageway through bad ground between the air lock and the tunnel started a blow-out that flooded the tunnel, drowning all but a few men who were near enough to the lock to escape. So the published description appeared in the same issue as a news account of the accident.

Early days on the Mississippi

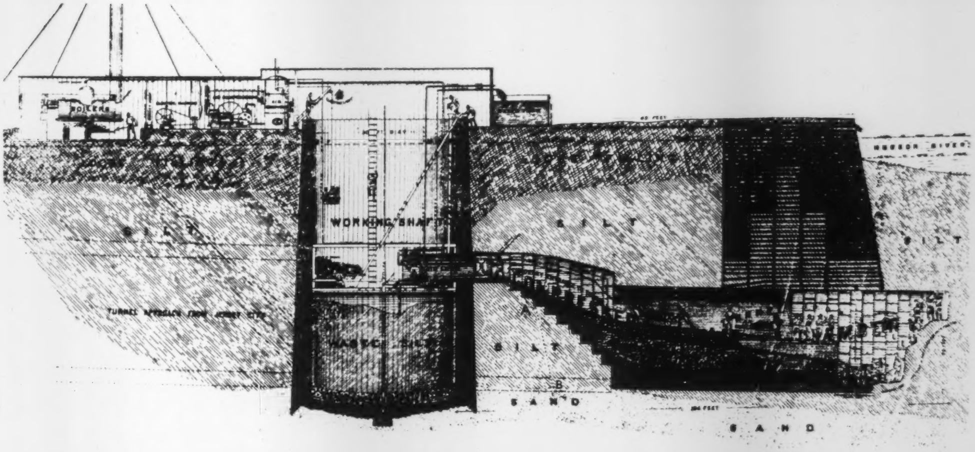
About this time too, James B. Eads was much in the news. He had completed the Mississippi River bridge at St. Louis and had won a settlement out of court from the Roeblings for infringement of his patent on the use of air locks for pneumatic caissons. Next he turned his attention to plans for making the Mississippi River deeper and maintaining a channel through the passes in its delta. A long controversy between Eads and General A. A. Humphreys, Chief of Engineers, who opposed his ideas as impractical, ensued. Humphreys had lost a previous battle with Eads on the matter of hindrances to navigation created by the St. Louis bridge.

Engineering News at first sided with General Humphreys, criticizing Eads for intemperate language. The issue revolved around depth measurements on which payments depended. When the Secretary of War ordered that reports on measurements be made to him instead of Humphreys, the editors appear to have concluded that Eads had some justification for his sharp words. In any event they wrote, "We hope no influence will be brought to bear to jeopardize the success of an experiment worth more to the profession, as an experiment alone, than it will cost, and in the event of success, of untold benefit to the country at large." Eads' plan did succeed in maintaining a channel of adequate depth without dredging, thus establishing a new principle of river hydraulics.

In a later issue the journal reported "Captain Eads has also another idea which he is prepared to defend. He advocates the use of cutoffs to permanently lower the flood line of the river so as to do away with levees entirely. No doubt if such a scheme is practicable, it would be a great saving of money as the expense of the levees as recommended by the commission is some $40,000,000." This idea was to be the center of another controversy several decades later, but the use of cutoffs finally was approved.

Pile driving formulas

Editors during those formative years of the 80's and 90's were Charles F. Wingate of the *Record*, and D. McN. Stauffer, Arthur M. Wellington and C. W. Baker for the *News*. Of these, Wellington became perhaps the best known as a result of his monumental book "The Economic Theory of the Location of Railways." He also acquired some unexpected fame by his handling of the subject of pile driving formulas. In 1888, a reader inquired as to the best formula for determining the safe bearing capacity of a pile. This letter was answered in the December 29 issue by John C. Trautwine who recommended use of the formula given in his "Civil Engineer's Pocket Book." Wellington did not agree with Mr. Trautwine's recommendation. He made a study of that formula, along with others, included in the Hering articles previously referred to, and wrote a long footnote to the Trautwine letter, which has since come to be recognized



WITH AN AIR LOCK but no shield a tunnel was started under the Hudson River in 1874. This sketch accompanied an account of the work written by editor Stauffer of the *News* following a visit to the heading in July, 1880. Before it appeared, a break near the airlock flooded the heading, drowning most of the workmen.

as one of the most important statements ever made on that subject.

In that footnote Wellington gave a very simple formula for determining the safe load on piles driven with a drop hammer, which he said produced better and more consistent results than some of the much more complicated ones, and could never lead the user astray as would some of the formulas then in use.

This formula soon became known as the *Engineering News* pile formula. Many discussions of it ensued; these were summed up by Wellington in the issue of Nov. 17, 1892, by a set of "Rules of Practice for Pile Driving and Safe Load of Piles." These rules included a modification of the drop hammer formula for use when piles were driven with a steam hammer. It is this formula that is commonly used today.

The Johnstown flood

Stauffer was the central figure in another famous instance of reporting when in 1889 the failure of an earth dam on the south fork of the Conemaugh River resulted in the inundation of Johnstown, Pa., with a loss of life estimated at 2,300. With F. P. Burt, an associate editor with a remarkable facility for making sketches, Stauffer immediately set out to provide the readers with a first-hand account. They had considerable difficulty in reaching the dam, lived on sandwiches for a couple of days, and spent one night in a barn. The resulting report was complete as to essential engineering details.

Soon after the failure, reports appeared in the daily papers to the effect that an incompetent engineer had been placed in charge of the reconstruction. The seriousness of that charge caused Wellington to make a thorough investigation. As a result he stated in a later issue: "Our information is positive, direct and unimpeachable that at no time during the process of rebuilding the dam was any engineer whatever, young or old, good or bad, known or unknown, engaged on or consulted as to the work – a fact which will be hailed by engineers everywhere with great satisfaction as relieving them as a body from a heavy burden of suspicion and reproach."

The Panama Canal

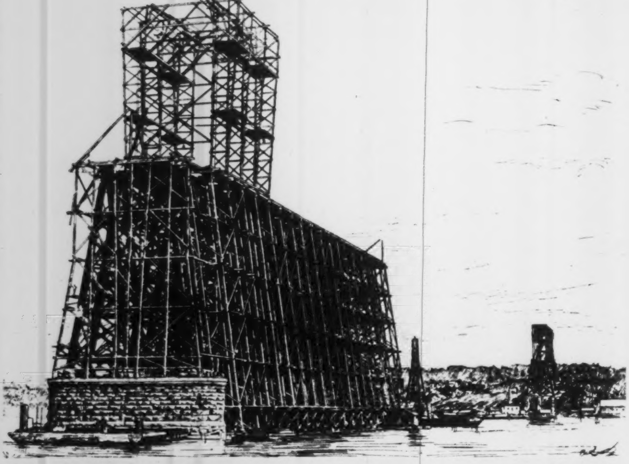
Stauffer was also the central figure in reporting on the Nicaragua Canal work. An ever increasing amount of space in *Engineering News* was given to the projected canals at Panama and Nicaragua during the 80's and 90's. For the most part, comment was critical as to the promotional methods of Ferdinand de Lesseps, the builder of the Suez Canal, who had organized a canal company for the Panama work. "By way of a fair start," the journal bluntly said, "the promoters modestly ask the proverbial guileless and trusting public for a nominal credit of $80,000,000."

The French began work at Panama actively in 1883 and continued until the company failed in 1888. This failure injected a spark of new life into the rival Nicaragua Canal project and, early in 1891, the president of the canal company invited Mr. Stauffer to join a party that was going down to see the work that had actually started at its eastern end. En route, his ship ran aground on a reef in the Caribbean. He was stranded for six days before being picked up by a rescue vessel and taken to Greytown, the port at the Atlantic end of the canal.

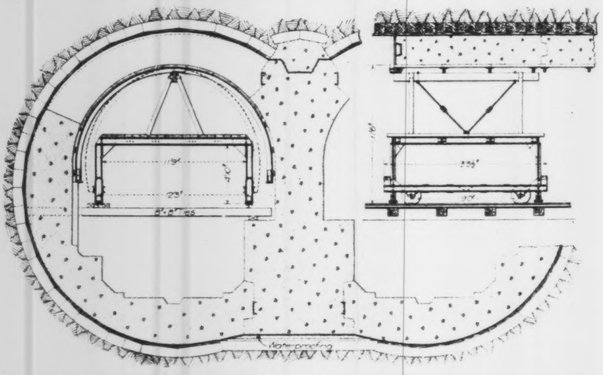
Publication of Stauffer's reports of progress on the never-to-be-completed Nicaragua Canal began in the issue of June 6, 1891. They were illustrated with drawings made by Burt from Stauffer's photographs. For twenty years thereafter both the News and the *Record* were filled with articles of controversy, criticism and construction as the scene shifted to Panama and to one of America's proudest engineering enterprises.

Typhoid fever and water supplies

Not only the chief editors but the other specialist members of the editorial staff were prominent in the important activities of those early journalistic days – just as they have continued to be. One of these staff members was M. N. Baker who had compiled the Manual of American Water Works, a listing of financial and technical information and a direc-



THE POUGHKEEPSIE BRIDGE was one of the great engineering undertakings of the early days. This *Engineering News* sketch of the falsework was laboriously made from a photograph by Frederick P. Burt of the staff because reproduction of photographs was too costly in 1887.



LINING SEQUENCE for the Detroit River railroad tunnel as illustrated in *Engineering Record* in 1908. The center wall was built in a drift ahead of the shields. Invert, side wall and crown lining followed.

tory of officials of all waterworks companies, which was published annually by the *News* from 1888-1897.

During that time Mr. Baker came into close contact with developments in water purification. Learning that William T. Sedgwick and Allen Hazen had written a paper entitled "Typhoid Fever in Chicago," that indicated a definite connection between a sewage-polluted water supply and high typhoid rate, Mr. Baker obtained a copy of the paper. Published in *Engineering News* along with two following editorials, the information attracted wide attention.

Appearing at a time when Chicago was preparing for an influx of people for the World's Columbian Exposition of 1893, the revelations are believed to have been a factor in the decision to pipe in spring water from Waukesha, Wis., for use on the fair grounds.

Engineering News, at any rate, began a campaign directed by Mr. Baker to arouse public interest in elimination of polluted water supplies. The water works associations and many state and local health agencies later participated in the campaign, and in 1917 Mr. Baker summed up the success of the endeavor in an editorial "Vanishing Typhoid and a Bit of Editorial Retrospect."

The Chicago drainage canal

Another staff member, C. S. Hill, who like M. N. Baker was to serve for nearly 50 years before he retired, chalked up another first in technical journalism just before the turn of the century. What he did was to elevate the planning and planting of construction to an equal status with design. Sent to Chicago to open a regional office there, he arrived to find the booming prosperity of the early 90's slipping off into another financial depression. The World's Fair was over, and the city was experiencing the inevitable letdown. The only large job under way was the drainage canal that the city had undertaken to reduce the pollution of its drinking water supply.

An on-the-foot survey of every one of the 27 miles of the canal convinced Hill that a wealth of useful information could be obtained there by diligent work. "To me," he said in later years, "the greatest revelation was that construction had a technique as profound as that of design; was just as true engineering art and science; was influenced by even more variables than was design; was as exacting of ingenuity and creative brain power as was design; and required the added capacity for shrewd business foresight and direction."

The response from contractor-readers to Hill's articles was enthusiastic. No such detailed analysis of a construction contractor's operations or presentation of his procedures had ever been published before. Everything was covered from plant layout to feeding the men. With a skill for which he later became well known, Hill had set down for contractors on other projects a job study of great value. A notable feature of these articles was the large number of schematic drawings of construction operations prepared from sketches he made on the job.

First reports on concrete

In the late 90's concrete in the U.S. was made with natural cement. Little portland cement was manufactured here, and engineers knew little about its properties. Almost no reinforced concrete was being used. Accounts in foreign journals of the use of portland cement in Europe and the bold adventures of French and German engineers in the use of reinforced concrete led Hill to conclude that information about this newer type of cement and its uses would be of great value to American engineers.

About that time, Hill said in later years, he came under the influence of the enthusiasm of E. L. Ransome and Fritz von Emperger, both of whom had been experimenting with reinforced concrete. The result was a number of articles, beginning about 1897, on cement manufacture and technology, and on reinforced concrete and concrete construction methods. Most of Hill's time for ten years was given over to the preparation of these articles. Out of them came "Reinforced Concrete" by A. W. Buel and C. S. Hill, published by *Engineering News* in 1903, the first treatise on reinforced concrete design and construction published in the English language.

Quebec bridge collapse

One warm August afternoon in 1907 about 100 men were working on the south arm of the great cantilever bridge that was being built across the St. Lawrence River in Quebec. There was a certain amount of tenseness in the air—the day before an inspector had been sent in haste to New York to report to the consulting engineer, Theodore Cooper, that one of the lower chord members was bent inward about 2 in. From New York the inspector was to go to Phoenixville, Pa., to carry the same word to the staff of the fabricators.

At that time the south cantilever over the river had been completed, the big traveler at its outer end was being dismantled, and erection of the suspended span with the lighter equipment was under way. Still the general foreman, knowing how the lives of his men depended on that bent or bending chord member, was frankly nervous, telling the resident engineer that he thought they were playing with death.

Without further warning, death came to 74 of the men, including the foreman and resident engineer. Slowly at first the outer end of the great span began to sink, and then with appalling swiftness the whole structure collapsed into a tangled mass of wreckage.

Mr. Cooper in New York, after hearing the inspector's report, had wired the plant at Phoenixville not to add any more weight to the bridge, but before the plant had relayed that word to Quebec, the collapse had occurred.

Editor C. W. Baker was vacationing in Vermont at the time. Immediately he telegraphed the New York office to have associate editor F. E. Schmitt join him at Quebec, since Schmitt had been following the work on the bridge closely.

Meeting in Quebec the next morning the two editors journeyed by trolley and on foot to the bridge, where they found Henry Holgate (head of the board set up by the Canadian government to report on the failure) examining the remains of the lower chord member that had been under observation just before the collapse.

The following noon Schmitt left for New York with his notes and sketches made on the ground, some photos from the engineer's file (taken before the accident) and some exposures of his own showing details of the collapse. At New York, while these photos were being developed and the sketches copied in a form for linecuts, Schmitt interviewed Theodore Cooper, consultant on the bridge, and prepared his report, spending the night before the next issue went into the mails in the print shop passing copy to the compositors as it was written.

The result was a detailed report of the accident and a discussion of its probable cause – which subsequently was fully supported in the findings of the official report on the failure. Nine years later, when the suspended span of the redesigned bridge fell into the river while being lifted into place from barges, a similar job of fast and complete reporting was carried out. This time an editorial staff member witnessed the actual collapse, and telephoned the news.

The Record expands

When the first collapse occurred at Quebec, *Engineering Record* had given no space to reporting the accident. At the time of the second failure, however, it gave its readers a fairly detailed account. This was due to the culmination of changes in editorial policy that had been taking place over many years.

During this time there was a definite trend away from articles on plumbing toward the broader field of sanitary engineering under the editorship of John M. Goodell. An outstanding example is found in a series of articles by George E. Waring on the importance of separate sanitary sewers, and another series on water wastes, which gave details of British practice in waste prevention. The *Record* also started publishing a series of articles on the construction operations on the Chicago drainage canal about a year after Hill's articles appeared in the *News*. That series was the first clear evidence of the growing competition between the two journals, which was to become so keen before the two were consolidated in 1917, and which revealed the *Record* as the champion of the field construction men.

In 1915 the *Record* editors undertook to challenge the leadership of the *News* in the field of concrete design and construction through the publication of a series of articles on the use of a microscope in determining how to improve the quality of concrete. They were written by Nathan C. Johnson, engineer of tests for the Raymond Concrete Pile Co. At the time the *Record* published the articles, the *News* had only given its readers a very brief summary of Mr. Johnson's findings as presented earlier before the A.S.T.M.

A few weeks later the *Record* presented additional results of Mr. Johnson's studies in an article entitled "Water, The Chief Factor In Making

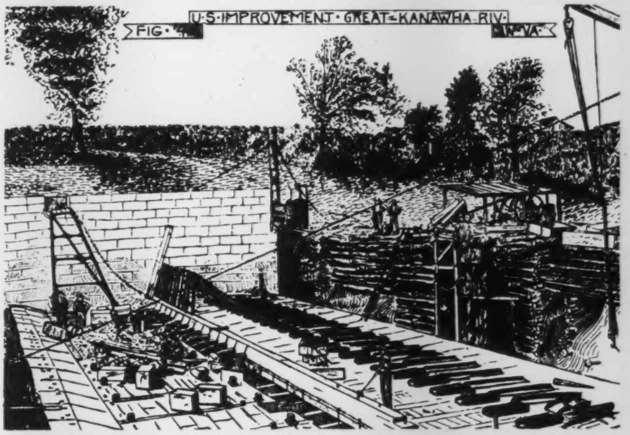


FIG.
U.S. IMPROVEMENT · GREAT KANAWHA RIV.
W.VA.

NAVIGATION PASS on the Great Kanawha River in West Virginia, as shown in *Engineering Record* in an article describing an improved type of movable dam.

Good Concrete," which pointed to the disadvantages of too wet a mix, a subject that had only been referred to briefly in the pages of the News up to that time and one that later years proved to be of outstanding importance.

Recruiting highway engineers for war

The first issue of *Engineering News-Record* appeared on April 5, 1917, just as the United States was entering World War I. Within a short time the editorial and business staffs of the new magazine undertook to aid in recruiting engineers for the regiments then being organized to go to France. Highway engineers were badly needed but the response to normal recruiting methods (that worked so well in getting men for the railroad regiments) was much too small, due chiefly to the fact that most of the eligible young engineers and construction men were out of reach of the recruiting points.

So it was decided to try to reach them through the pages of *Engineering News-Record*. To that end large notices telling of the need were published in its editorial pages, and many of the advertisers gave up their normal space for similar messages. Interested men were instructed to get in touch with the nearest recruiting station of the 23rd Engineers, the highway unit then being organized.

The response was both immediate and amazing. Hundreds of highway engineers and construction men from all over the country signed up. Later, like methods were used to find men for the quarrying and bridge building regiments and for the welding engineers.

An engineer war correspondent

By late summer of 1917, American engineer regiments were beginning to take their places alongside their British, Canadian and French fellows on widely separated sections of the active front in France, in French ports and on French highways and rail lines. To bring first-hand reports of this work to the readers, it was decided to send associate editor R. K. Tomlin to France as a war correspondent. The proposal was welcomed by the chief of Engineers, U. S. Army, and by December Tomlin was on his way to France. He visited most of the operations on which American engineers were engaged and wrote accounts of their work that were published currently by *Engineering News-Record*, and later reprinted in book form.

Construction cost data

Both *Engineering News* and *Engineering Record* began publishing contractors' bid prices soon after they were established, and later material prices and labor rates appeared occasionally. But publication of these data on a regular basis was not started until the end of 1909.

This regular publication of material prices and labor rates was a great help to engineers in making estimates of proposed work and to contractors in preparing bids, especially in areas where they were not familiar with local prices.

After the first World War, when many engineers became engaged in valuation work, these monthly figures also proved to be of value in determining the cost of work done in earlier years.

Out of this application of current construction data to valuation work came the realization that an index, which would show trends in construction costs similar to the index compiled by the Bureau of Labor Statistics to show the trend in living costs, would be of great value not only to the construction industry but also to utility commissions and financial houses. Consequently, such an index was compiled in 1921, basing it on 1913, the last normal prewar year, to which the number 100 was assigned.

Later in the same year, the ENR staff compiled a volume index, also based on 1913, which makes it possible to compare the physical volume of construction from year to year regardless of fluctuations in costs.

Introducing soil mechanics

During the early 20's, *Engineering News-Record* pioneered in publishing information about what is now commonly known as soil mechanics. This began with the publication in September, 1920, of a paper by the then little-known scientist, Karl Terzaghi who, while teaching at Robert College in Turkey, had undertaken to develop new earth pressure theories.

The early studies reported in this paper appeared to be so significant to F. E. Schmitt, editor of ENR, that he suggested to Dr. Terzaghi that he send in more detailed reports of his later studies and findings. These were published as a series of eight articles in the latter part of 1925. In 1926 the series was reprinted in pamphlet form, and for a considerable time this was the only English text on that subject.

Practical applications of the theories propounded by Terzaghi soon began in this country. Early in the 30's, the Los Angeles Bureau of Waterworks and Supply began applying them to the compaction of soils in large earth dams. The outcome was the development of an entirely new procedure for engineering control of such work. Included were simple tests for determining the suitability of materials for earth dams and for checking the compaction.

These methods were described in four articles written by R. R. Proctor, field engineer of the bureau, which were published by ENR in 1933.

Three years later ENR published another notable series of articles reporting further developments in the application of the principle of soil mechanics to earth dam construction. These related to work on dams built for flood control in the Muskingum River valley in Ohio, and were written by Theodore T. Knappen and R. R. Philippe of the U.S. Engineer Office at Zanesville, Ohio. Reprinted, both series still are in demand.

Great floods

From the time of the Johnstown flood, the reporting of such disasters has been a basic tenet of *News-Record* practice, on the ground that lessons from failures are potent aids to better design and construction. As flood control structures—dams, levees, cutoffs, wasteways and the like—multiplied, accounts of their functioning under flood loads had similar engineering significance.

Only by first-hand eye witness accounts can such news be brought to the reader. Thus it was that in 1927, W. W. DeBerard spent ten weeks in the lower Mississippi Valley studying the effects of that year's disastrous flood and discussing with local people the several proposals for flood protection that were then under consideration. These observations were published in a series of articles, which provided the readers with the background against which to appraise the new flood control plans when they were made public late in 1927.

Readers will recall that in 1936 the floods and the other results of the New England hurricane were similarly reported by Waldo Bowman, V. T. Boughton, E. J. Cleary and H. W. Richardson, who covered the various devastated areas in a matter of a few days for publication in the next week's issue. The process was repeated in 1937 by both DeBerard and Richardson on the Mississippi and Ohio river floods.

The relative importance attached to such field reporting as compared to armchair writing is summed up in an editorial department adage: Mud on your shoes is a badge of honor, a shine on the seat of your pants a disgrace.

St. Francis Dam failure

On March 12, 1928, St. Francis Dam in southern California failed. In the March 22 issue appeared an 8-page report by N. A. Bowers—written within 36 hours of the failure and including complete pictures and drawings. In the same issue an editorial said: "A great dam has gone out. For the first time in history a high dam of massive masonry has failed and every fear of the destruction pent up in such work is realized. In human respects, the memorable Johnstown catastrophe of 39 years was greater. But the washing out of an old neglected earth dam was not an engineering tragedy as was the destruction of the St. Francis Dam. Here the highest embodiment of modern dam building science crumbled into ruin, taking a toll of hundreds of lives as the price of mistaken confidence in its strength.

"No final statement of why the dam failed can be made until the official inquiries already begun are concluded. But Mr. Bowers' examination of the site as reported in the following pages points unmistakably to fatal weakness in the foundation. . . . The present disaster contains no fact or happening that would justify restriction of dam construction. It points the need, however, for an effective check on individual judgment concerning foundations where many lives are at stake."

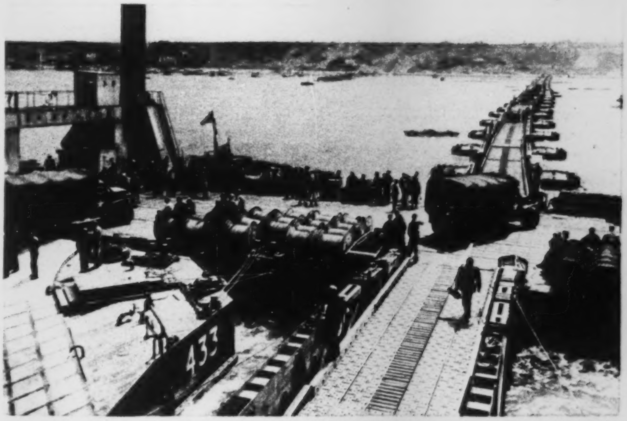
The official examination and conclusions bore out these original contentions. As a result, California passed a law requiring all dam designs to have state approval, thus setting up a protective measure that had been proposed by the editors of *Engineering News* following the failure of the dam that caused the Johnstown flood in 1889.

Many special reports

Recognizing that it is not enough merely to publish the news of the industry week by week and descriptions of important projects as they occur, *Engineering News-Record* has consistently followed a practice of periodically focusing attention on important problems or situations that would benefit from round-up and analysis of available information. Thus in 1920 a report on the future of inland water transportation was published. In 1923, a survey of reclamation policies and practice appeared at a time when the country's thinking with respect to this important engineering operation was undergoing question and criticism. In 1924, C. S. Hill published a long series of articles on winter construction, bringing to the attention of the industry many practices which would enable the seasonal peak of operations which occurred in the spring, summer and fall to be evened out over a twelve-month period.

Wartime construction

Long before the United States became directly involved in World War II, it became obvious that the struggle was to be more of an engineer's war than any previous one. Also because of security requirements, the normal type of reporting could not be followed, yet there was urgent need for widespread dissemination of information about new designs and methods of construction.



NEWS OF THE INVASION PORTS and the part played by American engineers in building them off the coast of France in 1944 was brought to the readers of ENR in first-hand accounts.

As this latter need was fully appreciated by the engineering heads of the Army, Navy and Air Force, arrangements soon were made for passes for editors to visit restricted operations and for the fast clearance of the copy they produced. As a result, *Engineering News-Record* was able to report details of methods and materials used on war plants and at many military installations without violation of security restrictions.

Later, as it became certain that this country would soon join the conflict, it became evident to Waldo Bowman, who had become editor, that adequate coverage of the civil engineering operations on the farflung battle fronts ultimately would call for on-the-scene staff reporting, just as would any construction job on the home front.

The first opportunity to institute this practice came in 1942 when our government started to build a highway to Alaska. Engineering interest in the project ran high, but specific information as to how the work was being accomplished was almost completely lacking. To meet this need, with the cooperation of the Army Engineers and the Bureau of Public Roads, H. W. Richardson was sent to prepare first-hand reports.

Beginning at the south end, Richardson worked north, sending in his notes and pictures by air mail. He was present at the "holing through" of the pioneer road near the boundary between Yukon Territory and Alaska, getting the only pictures of that historic event. And then by making his way to the upper end of the highway, he became the first person to travel over the entire road.

Similarly in 1943 when the U. S. government undertook to complete the Inter-American highway, A. N. Carter was sent to visit the many scattered construction operations between Mexico and Panama.

By that time the war activities of American engineers were reaching into the far corners of the globe. To meet this need for wider coverage, Bowman himself went to England, North Africa and Persia while E. J. Cleary took over the assignment in South America, when sanitation was the requirement of first magnitude with which American engineers were grappling. Richardson departed on another visit to Alaska and on out to the Aleutian Islands.

The following year N. A. Bowers was given an assignment to cover airfield, road and port work in the South Pacific, a trip that took him all the way to Australia. Bowman went to Europe again that year to cover operations on the continent, particularly port camp and road construction and the great bridging operations attendant to crossing the Rhine. At the same time Richardson went to the Philippines and Japan on a trip that included coverage of the atomic destruction at Hiroshima.

Use of the military air mail services frequently made it possible for *Engineering News-Record* to give its readers re-

GENEALOGICAL HIGHLIGHTS

Engineering News

1874	(April) Started in Chicago by George H. Frost as *The Engineer & Surveyor*. Mr. Frost also was editor.
1874	(May) Name changed to *Engineer, Architect and Surveyor*.
1875	Name changed to *Engineering News*.
1876	Weekly publication begun.
1879	Offices moved to New York.
1882	Name changed to *Engineering News and American Contract Journal*.
1883	D. McN. Stauffer engaged as editor.
1887	Arthur M. Wellington joined staff as co-editor with Stauffer. Name changed back to *Engineering News*.
1894	Charles Whiting Baker became editor.
1895	Regional editorial office established in Chicago with C. S. Hill as first regional editor.
1911	John A. Hill purchased the paper.
1914	Regional editorial office established in San Francisco with N. A. Bowers as regional editor.

Engineering Record

1877	(December) Started in New York by Henry C. Meyer as *The Plumber and Sanitary Engineer*, with Charles F. Wingate as editor.
1880	Named changed to *The Sanitary Engineer* and weekly publication begun. Mr. Meyer assumed editorial direction of the paper.
1886	Name changed to *The Sanitary, Engineer and Construction Record*.
1887	Name changed to *The Engineering and Building Record*.
1890	Name changed to *The Engineering Record*.
1897	John M. Goodell made editor.
1906	Regional editorial office established in Chicago with S. T. Henry as first regional editor.
1912	E. J. Mehren became editor.

Engineering News-Record

1917	Consolidation of *Engineering News* and *Engineering Record* when McGraw-Hill Publishing Co. was formed. Charles Whiting Baker made editor of new magazine, and E. J. Mehren a vice president of the company.
1917	News Bureau opened in Washington, D. C.
1918	E. J. Mehren became editor.
1918	Purchased and absorbed both *The Contractor* and *The Contractors Review*.
1924	Frank W. Wight made editor.
1927	Willard Chevalier, business manager and former associate editor became publishing director after Frank Wight's death.
1928	F. E. Schmitt became editor.
1940	Waldo Bowman became editor.
1947	Regional editorial office established in Cleveland with J. Roland Carr as regional editor.

ports from these editor-war correspondents within a week or two after they were written. The most spectacular example of this was Bowman's report of the collapse of the Remagen Bridge over the Rhine while American engineers were trying to repair it. Bowman had spent the morning on the bridge, a scant two hours before it collapsed. Two weeks after the failure ENR published a complete report together with pictures and sketches, an account that would never have been a part of the historical record of civil engineering without *Engineering News-Record's* practice of personal reporting of news.

The history of *Engineering News-Record* can well close with that incident because it provides a connecting link to the time some seventy years earlier when the first editor by a like fortuitous circumstance was similarly at hand when an accident befell a bridge that was in the news of his day, the Brooklyn Bridge.

There have been many improvements in means for collecting news since the days when George H. Frost and Henry Meyer launched their little journals, and many improvements in type and cuts and form of presentation. There have also been many changes in the construction industry and in the reading habits and needs of its members.

Many more sources of information are available. Developing civilization has created new diversions (some necessary, others merely tempting) to reduce reading time. The complexity and scope of engineering and construction have increased tremendously. Problems with labor and with legislation that affects business, have become the necessary concern of engineers and contractors.

All these things have had an effect in changing magazines which seek to serve their readers adequately. They have had an effect on *Engineering News-Record.* Nevertheless, the journal for which Mr. Frost wrote that first bridge accident report and the one that carried the Remagen Bridge report to its readers had one thing in common. It was summed up by James H. McGraw in the first issue of *Engineering News-Record,* April 5, 1917 in which he said, "The paper must be above personalities, above the editors and publishers – it must be an institution. Its principles must be so grounded in truth that they cannot be changed, its policies so well crystallized that they appear unconsciously in every issue and impress themselves on the reader, its traditions so entwined with the interests of its readers that it cannot without an unthinkable shock divorce itself from their service."

Principles, policies and traditions are still basic. It is *Engineering News-Record's* intent that on them shall be builded the kind of reporting and history-recording service that is required by a profession and an industry upon whose activities and works so much of America's progress depends.

To report the news more fully and faster, to relate it to its proper background, to point out its significance when that can be discerned – that is one of the blocks with which to build. Another will be to describe and appraise the technical developments of the art whether from the field or the office, at home or abroad. And a third will be to present economic and business facts with a frequency and an accuracy commensurate with the needs of successful construction enterprise.

Lastly, as a block of some importance to the complete edifice, the magazine shall vigorously, but with humility, continuously and with all the fairness and foresight that it can muster, praise and prod its readers to make the kind of history of civil engineering and construction that can be read with pride and usefulness when the time comes for another generation to take stock of the legacy that has been left it.

Molding the Future

A SYMPOSIUM OF PROVED AND PROVOCATIVE IDEAS FOR BUILDING A GREATER AMERICA

1874 1949

What are the outstanding problems whose solution would have the most influence on future progress? Asked of over a hundred top-ranking specialists, this question inaugurated the search for the authoritative articles presented in the following pages—articles immediately useful in molding America's future.

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AN ARTICLE TO MOLD THE FUTURE

Take the Waste Out of Fire Protection

John W. Dunham
Assistant Chief Structural Engineer
Public Buildings Administration, Washington, D. C.

MANY HARD-EARNED dollars and tons of much-needed construction materials are being wasted annually by incorporating excessive fire-resistance in buildings.

This can be demonstrated by the fire record and by tests and surveys conducted by the National Bureau of Standards.

Prevention of this needless waste is a challenge to building officials and designers. Through their efforts, fire-resistance provisions in building codes and in design specifications can be made more realistic. More economical buildings will result, with no decrease in safety to life.

Building codes are established for public safety. But how far should they go? In particular, how much fire resistance should be required?

The answer is: Only as much as needed for reasonable protection to the lives and property of the community. Beyond that, building codes should not go. The owner can—and usually does—provide further safeguards to preserve his investment, or to get more favorable insurance rates. But that is the owner's business, not that of the community.

Building codes legitimately attempt to achieve safety to life, chiefly—though not exclusively—through the provision of adequate exits and limitations of heights and areas. The writers of such codes should keep in mind, however, that the incorporation of fire resistance in a structure is largely—though again not exclusively—a matter of property protection.

Thus, in pursuing proper objectives, building codes require that certain buildings (because of size, location or occupancies) be practically immune to destruction by fire, either inside or outside. Such a requirement is obviously reasonable, for instance, for buildings of unlimited size in closely built areas. It is also logical for buildings of any considerable size or height in which people are confined for penal purposes or in which, for any reason, the liberty of inmates is restricted.

How codes specify fire resistance

Most codes set up a type of construction to accomplish this purpose—variously called "fireproof," "fire-resistive," or "fully fire-resistive." In each case, it is the type having the greatest resistance to fire.

In many of the older codes, the fire resistance requirements for these buildings are 4 hr. for exterior walls, fire walls, bearing walls and columns, and 3 hr. for beams, girders, floors and roofs. In other codes, the acceptable constructions are prescribed in terms of materials and thicknesses that result in structural elements roughly comparable in fire resistance to those noted (8 in. of brick or concrete for walls, and 2 to 3 in. of concrete cover for beams, depending on the grade of concrete).

But, it is a fair question whether so much fire resistance is needed to accomplish the required immunity. At least in some cases, wouldn't more economical constructions with lower ratings suffice? Recent studies offer an answer. Correlating fire severity with combustible contents of buildings, and combustible contents with occupancy, they indicate the fire resistance actually required to be provided for different occupancies.

Fire load vs. fire severity

The relation between the possible fire severity in a so-called "fireproof" building and the amounts of combustibles present in that structure are indicated in the accompanying table, prepared by S. H. Ingberg of the National Bureau of Standards. The weights given are equivalent weights of combustibles having calorific values per pound approximately equal to wood and paper; i.e., 7,000 to 8,000 Btu. per lb. Let us call these weights per square foot the "fire load"—a term borrowed from the British.

The amounts of combustibles commonly associated with many occupancies have been established by surveys of apartment buildings, offices, schools, hospitals and warehouses, and have been reported in Building Materials and Structures Report BMS 92, published by the NBS. Additional information has been acquired in unpublished surveys made for the NBS by the Public Buildings Administration, covering department stores, furniture factories, mattress factories, warehouses, a printing plant, newspaper plant, dress factory and clothing factory.

In general, the fire load in occupancies of the residential, assembly and institutional type rarely exceeded 10

A Spectacular fire took the lives of approximately one-third of the guests at the Winecoff Hotel, Atlanta, Ga., in 1946 . . .

But no structural damage of significance occurred. Although the fire lasted nearly 3 hr., it was of not over 1-hr. severity, whereas the structure could withstand safely a fire of twice that. (Wide World Photos)

lb. per. sq. ft. In office and mercantile occupancies, it seldom exceeded 20 lb. per sq. ft. and then only in limited areas used for file rooms and storage. Combustible contents found in industrial occupancies were more variable, but seldom were over 30 lb. per sq. ft., except in storage areas. On the other hand, the fire loads in storage occupancies and in storage areas in connection with industrial occupancies may be greater than 100 lb. per sq. ft. These figures include an allowance for combustible trim and flooring.

Resistance based on fire load

A comparison of the above fire loads with the values in the table indicates the amount of resistance required in the several occupancies to avoid the danger of collapse from a fire within the building.

In the case of the heavily loaded occupancies, such as storage, it shows that a higher fire resistance than heretofore required must be provided. Or else, construction with a definite resistance must be used, and provision made for extinguishing the fire before that resistance can be overcome. In this instance, it appears that no economies should be attempted beyond the requirements currently in force.

For other occupancies—residential, institutional, assembly, business and mercantile—important economies apparently are possible without sacrificing ability to withstand a complete burn-out without collapse. For instance, for residential occupancies, including apartments and hotels (fire load of 10 lb.), it is evident that a 1-hr. fire resistance would be sufficient. A 1½-hr. resistance would give an ample margin of safety.

In support of this contention is the performance of the structural elements of the Winecoff Hotel, Atlanta, Ga. during the Dec. 7, 1946, fire (ENR Dec. 19, 1946, vol. p. 842). Complete burn-out occurred in most of the rooms on the ninth floor. The partitions there were 3-in. terra cotta, plastered on both sides, which has a fire resistance of 45 min. to 1 hr. They were exposed to fire on both sides; yet in only one instance was a partition broken through—and that in a very small area.

SEVERITY OF FIRES

Total Combustible Content (Incl. finish floor and trim)		Equivalent Fire Severity	
Lb. per Sq. Ft. of floor area	Assumed Btu. per sq. ft. of floor area	hr.	min.
5	40,000	0	30
10	80,000	1	00
15	120,000	1	30
20	160,000	2	00
30	240,000	3	00
40	320,000	4	30
50	380,000	6	00
60	430,000	7	30
70	500,000	9	00

Excessive resistance provided

It is obvious that the fire severity (not duration) in this part of the building, where damage was greatest, did not exceed 1 hr. That, of course, is what should be expected from the Winecoff fire load, which could not have exceeded 10 lb. per sq. ft. in the rooms. The building has been likened to a good stove because it contained the fire without collapse.

The fire resistance of the frame was probably in the neighborhood of 2 hr. If this building had had 3-hr. floors and 4-hr. columns, it would not have performed one bit better, nor would it have prevented the appalling loss of life that occurred. A 1½-hr. fire resistance in the frame would have been ample.

The foregoing considerations indicate that buildings for occupancies with less than 30-lb. per sq. ft. fire load may safely be constructed with lower fire-resistance ratings than those required by the older codes.

The difference between constructions having ratings required by the older codes and those having ratings that will provide needed protection are shown in the accompanying sketches.

Since there are many combinations of materials that will provide a given fire resistance, it is obvious that the ones illustrated are offered only as typical examples. Some parts of them are based on values obtained from tables of fire-resistance ratings; others have been estimated from ratings of similar constructions. BMS 92 and TRBM-44, both published by NBS, are the most comprehensive sources of such ratings at present.

Wall resistance rationalized

The requirements for exterior walls in "fireproof" buildings should be considered separately from those for the other structural elements, because the situation differs in several important respects. Except for party walls, the exposure to fire on the outside of exterior walls is lighter than on the interior. Assuming that adjacent buildings conform to the same code, there is on the outside either an adjoining wall of comparable construction or an open space. In the first instance, the walls combine to prevent the spread of fire from one building to the other. In the second case, the open space acts to cut the exposure enormously. It is very doubtful that an exposure equivalent to 1-hr. fire severity can be produced on a wall across an intervening space of 20 ft.

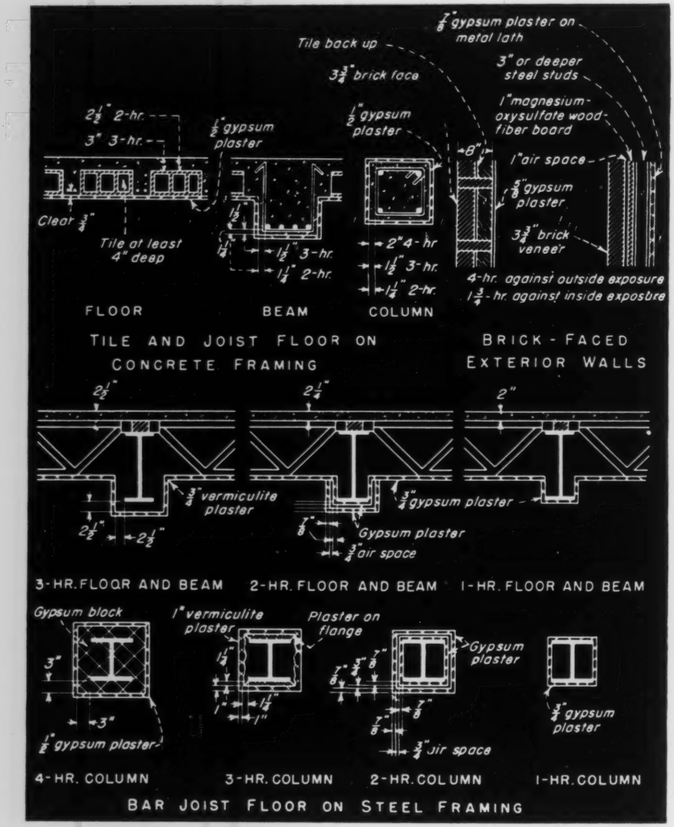
Two types of exterior walls must be considered: bearing and panel. For exterior bearing walls, resistance to inside exposure should be the same as for other structural elements. Resistance to outside exposure, however, could reasonably be from 2 hr. at zero spacing between buildings to 1 hr. at 20-ft. spacing. In support of the latter figure, it is pertinent to point out that, with a 20-ft. separation, windows will have to be permitted, and even with shutters they will not afford better protection than the 1-hr. resistance proposed for the wall.

Panel walls, which constitute the exterior walls in most fireproof buildings, have an especially strong claim to separate consideration. Since structural failure of such a wall will not cause collapse of the structure, it is reasonable to permit a lower fire resistance against inside exposure than that required for the other structural elements. This resistance also could safely vary from 2 hr. with zero separation to 1 hr. with a separation of 20 ft.

Incidentally, when there is an open space outside of an exterior wall, the transmission of temperature, due to inside exposure, is of much less practical importance than it would be if there were an adjoining building. *It may be worth while to consider whether the requirements of the standard test in this respect should be changed.* A similar modification for roof construction is under consideration.

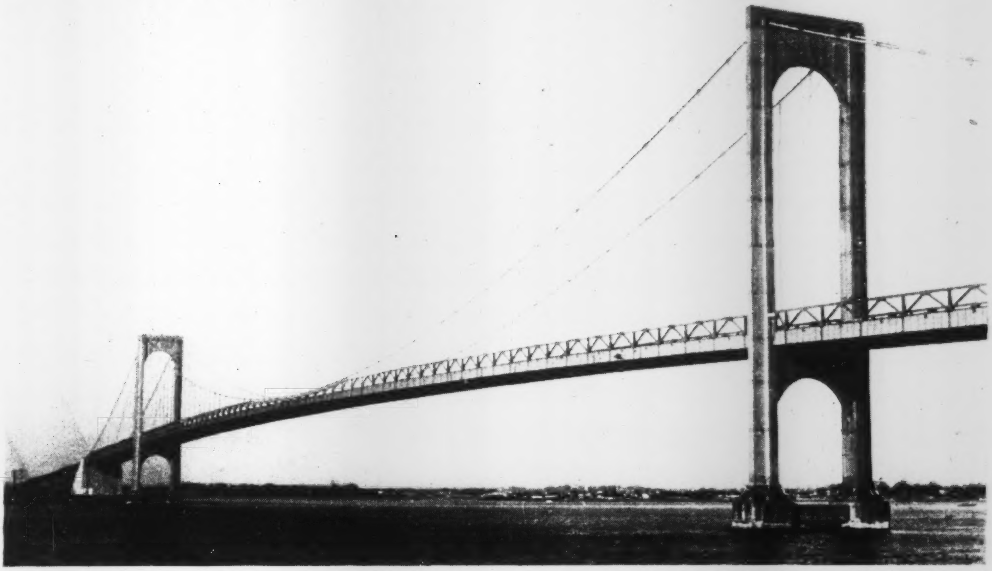
The blanket requirement in the older codes for a 4-hr. resistance for exterior walls probably arose from conditions that no longer obtain. When those requirements were written almost any wall that would have been structurally satisfactory had a fire resistance of 4 hr. or more. Now, lighter constructions are available, and the resistance to exposure is not necessarily the same for both sides. To make possible the economical and safe utilization of these constructions, the fire-resistance requirements imposed should be no higher than required for safety.

In answer to our question then, it is concluded that economies in fireproof construction are possible and reasonable. To achieve them, the fire-protection parts of building codes must be based upon quantitative data where they are available. Moreover, they must be developed by engineering reasoning of a quality comparable to that which has been employed in establishing the structural requirements.


⅞" gypsum plaster on metal lath
Tile back up
3" or deeper steel studs
3¾" brick face
1" magnesium-oxysulfate wood-fiber board
2½" 2-hr.
3" 3-hr.
½" gypsum plaster
½" gypsum plaster
8"
1" air space
⅝" gypsum plaster
Clear ¾"
Tile at least 4" deep
1½"
1¼"
1½" 3-hr.
1¼" 2-hr.
2" 4-hr
1½" 3-hr.
1¼" 2-hr.
3¾" brick veneer
4-hr. against outside exposure
1¾-hr. against inside exposure
FLOOR
BEAM
COLUMN
TILE AND JOIST FLOOR ON CONCRETE FRAMING
BRICK-FACED EXTERIOR WALLS
2½"
2¼"
2"
¾" vermiculite plaster
2½"
2½"
¾" gypsum plaster
⅞"
Gypsum plaster
¾" air space
3-HR. FLOOR AND BEAM
2-HR. FLOOR AND BEAM
1-HR. FLOOR AND BEAM
Gypsum block
1" vermiculite plaster
Plaster on flange
Gypsum plaster
3"
3"
½" gypsum plaster
1¼"
1¼"
1"
1"
⅞"
¾"
⅞"
⅞"
⅞"
¾" air space
¾" gypsum plaster
4-HR. COLUMN
3-HR. COLUMN
2-HR. COLUMN
1-HR. COLUMN
BAR JOIST FLOOR ON STEEL FRAMING

FIRE RESISTANCE RATINGS of typical constructions. Concrete aggregate is assumed to contain not over 30 percent quartz, chert, flint or similar material. Gypsum plaster is considered part of the protection over slab steel.

AN ARTICLE TO MOLD THE FUTURE



BRONX-WHITESTONE BRIDGE at New York to which stiffening trusses were added to the original stiffening girders and diagonal stays installed from the tower tops to eliminate objectional oscillations.

Suspension Bridges Are Safe Again

F. H. Frankland
Frankland and Lienhard
Consulting Engineers
New York, N. Y.

It may confidently be expected that during the next few decades many long-span suspension bridges will be built in this country to service our ever-expanding highway transportation system. It can be stated with equal confidence that now, ten years after the Tacoma Narrows Bridge failed from aerodynamic instability, no future suspension bridges need be threatened by the same cause of failure.

As a result of one of the greatest "trouble hunts" in structural engineering history, the suspension bridge is safe again. It is possible to list the criteria for such safety, and there are four large bridges now under construction or in the design stage that utilize these criteria.

When the Tacoma Narrows Bridge failed due to unknown aerodynamic forces, all suspension bridges immediately became suspect. A few existing structures required remedial measures to reduce threatening vibrations, but the great majority were adjudged amply safe without change. Nevertheless, they were safe not because they had been consciously designed to resist aerodynamic forces, but simply because their proportions and characteristics—fixed by other considerations—happened to be satisfactory. Under the circumstances, it was imperative to institute studies that would reveal the basic requirements for aerodynamic stability in suspension bridges.

In cooperation with the Public Roads Administration a representative group of suspension bridge experts formed the Advisory Board on the Investigation of Suspension Bridges, and formulated a comprehensive program of model tests and theoretical studies. In addition, observations of the performance of existing bridges under aerodynamic forces were instituted. The investigations have, to a very great extent, clarified the character of the aerodynamic forces involved. They have also revealed the response of the structures to such forces, so that, together with the results of studies of existing bridges, we now know in a general but definite way the influences of weight, proportions, and certain structural features on the dynamic behavior of suspension bridges.

The use of weight alone as a steadying influence on oscillations is but a crude and expensive means of attaining the desired objective. The proportions of side span to main span lengths, the sag ratio of the cable, the depth of the stiffening trusses, the width between trusses, all have a direct effect on the stability of the structure against torsion and vertical oscillations. Structural features, such as lateral bracing and details to absorb energy that would otherwise be reflected in objectionable vibration and oscillation, are an important part of the desired end of a well-balanced design which is proof against catastrophic behavior under any possible aerodynamic forces.

Bridge activity since Tacoma

About the time of the Tacoma Bridge failure there existed certain bridges that exhibited undesirable oscillations under specific aerodynamic forces, and to which remedial experiments were applied. To the Whitestone Bridge were added auxiliary trusses attached to the tops of the original stiffening girders, diagonal ties between cables and girders at the center of the span, and diagonal stays from the tops of the towers to the stiffing girders. In the cases of the Thousand Islands and Deer Isle Bridges, diagonal stays at the towers and diagonal ties at the center of the main span were installed. The use of these expedients materially reduced the amplitudes of vertical vibrations in these three bridges.

New suspension bridge undertakings in the ensuing 10 years were confined to a replacement structure for Tacoma, but now three major structures are in the design stage or beyond. These are the Chesapeake Bay Bridge near Baltimore, the Hudson River Bridge at Kingston, and the Delaware River Bridge at Wilmington. Each has been designed with provision for adequate stiffness against torsion and vertical motion in the suspended structure. In addition particular care has been taken to avoid the effects of aerodynamic forces tending to generate undesirable motions such as flutter which, when present, invariably leads to a synchronization of oscillations, which may be highly dangerous.

The resulting cross-sections of the Tacoma and Kingston bridges are shown in the accompanying drawing. The one for the Delaware River Bridge is similar in that two planes of lateral bracing are provided to add to its torsional stiffness. With a 2150-ft. main span, it will use 20-ft. deep stiffening trusses set 61 ft. apart center to center. Howard, Needles, Tammen & Bergendoff are the consulting engineers, with O. H. Ammann the consultant on the suspension bridge design.

What the studies will furnish

Some of the new provisions result from original analysis by the designers, but most of them stem from the advisory board studies. The results of the theoretical investigations are about to be published under the title of "The Mathematical Theory of Vibration in Suspension Bridges." This work will present a history of early suspension bridge failures accompanied by a general statement of the dynamic problems involved, and makes available to suspension bridge designers the following information:

(a) An hypothesis explaining the excitation of oscillations in suspension bridges.

(b) A definition of the conditions determining the "steady state" amplitude, and a choice of measures for reducing it, if necessary. Section model tests of the suspended structure, as applying to any particular design, required to supply the unknowns in the aforementioned hypothesis, have been formulated.

(c) An analysis of the free vibrations of a suspension bridge, and an "exact" method, involving the solution of the fourth order differential equation of forces during vibration. Applications are given for various values of girder stiffness.

(d) An approximate method, based on energy relationships and representing the configuration of the structure by Fourier series. By using the latter method, the effects of dead load, span ratio, truss stiffness, and cable sag can be investigated, and the distribution of energy storage in the various elements of the structure determined.

(e) A special development of the energy method for bridges with continuous stiffening trusses. Numerical examples are given for comparisons of the influences of continuous trusses and trusses hinged at the towers.

(f) Means of applying the energy method to torsional vibration, the suspended structure, with top and bottom laterals, being considered as a thin-walled tube, in which case chord stresses are small and the area of the web members is the dominant factor. In case but one lateral system is used the chord area and truss depth determine the resistance of the stiffening system to torsional displacement.

(g) A demonstration of the fact that the addition of a second plane of laterals materially increases the frequency of torsional modes, as also the frequency of torsional movement is materially increased by the expedient of a stiff tie between cable and truss at midspan. It is now known that torsional rigidity in the towers is responsible for a substantial increase in torsional frequency, and that the bending factor of the towers has but a small influence on the vertical modes.

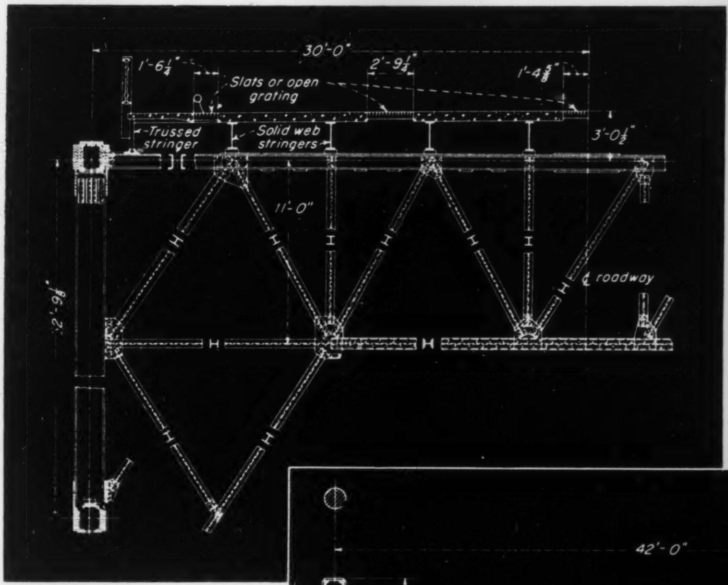
(h) An analysis by the energy method of the effect of diagonal stays from the tops of the towers to the stiffening trusses. This is applied only to the basic modes of motion because of the complex redundancy of the resulting system. Simplifying assumptions have been made in the analysis of these modes. If the bridge designer uses diagonal stays it is shown that, in order to make such an expedient effective, the most efficient location of the stay attachment to the stiffening truss must be determined individually for each structure. An easy method has been developed for determining the static stresses and deflections as influenced by stays, as the increased redundancy due to their use makes it impracticable to apply the so-called "exact" methods involving a non-linear differential equation.

(i) An explanation of the character, influence, and mathematical treatment of "damping capacity." The sources of damping have been classified as "internal," "Coulomb" and "atmospheric." The economic feasibility of designing for increased damping has been studied analytically, and numerical examples have been developed. It has been shown that structural damping is beneficial to a degree determined by the increase in critical wind velocity. The relation between the full model and section models tested has been given theoretically for the different forms of motion. Short cuts and convenient tables have now been developed for analyzing this type of oscillation.

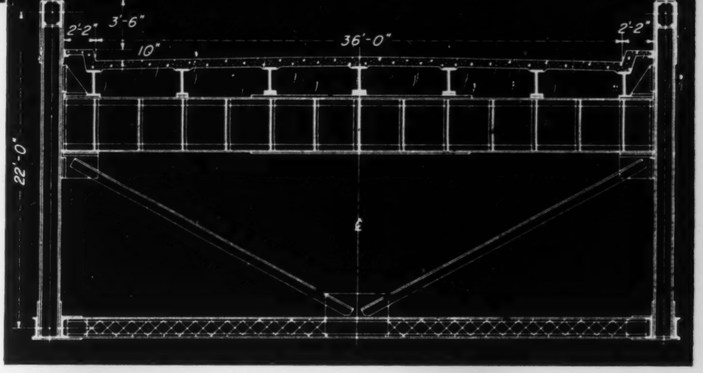
(j) A plot of the moments and deflections calculated by the linearized theory for fifteen live load conditions. Similar curves for comparison are developed from load tests on a model, whereby the analytical results are shown to be well within the limits of accuracy requisite for sound and skillful design.

As a result of applying the information developed by research, the new design for the Second Tacoma Narrows Bridge provides about 50 percent increase in the dead load of the suspended structure as compared to the

New bridges take aerodynamic forces into account:



SECOND TACOMA NARROWS BRIDGE in Washington will have deep stiffening trusses, top and bottom lateral systems, trussed stringers at edge of roadway and wind slots in the roadway slab. Charles E. Andrew is the designer of this 2800-ft. span bridge.



KINGSTON - RHINECLIFF BRIDGE in New York utilizes 22-ft. deep stiffening trusses so as to comply generously with the minimum requirements of 1/100 of the 1700-ft. span. Only preliminary designs have been completed. D. B. Steinman is the designer.

first bridge. This additional dead weight is mainly due to the greater width and traffic capacity of the new bridge and adds substantially to its resistance to dynamic wind forces. Trusses are substituted for the plate girders of the original design, and thereby a very considerable increase in vertical elastic stiffness is achieved. The location of the deck near the horizontal plane of the top chords of the stiffening trusses and the provision of a lateral system in the plane of the bottom chords provides a high factor against vertical and torsional oscillations. In the light of knowledge, at the time the design for the new bridge was completed, features insuring adequate mass and elastic and frictional resistance of the structure were mainly relied upon to assure aerodynamic stability.

It is probable that air slots in bridge roadways, as used on the new Tacoma Narrows Bridge, will contribute a small amount to the behavior of a suspension bridge in resisting torsional and vertical movements, although such slots located in the plane of the roadway adjacent to the stiffening trusses will very definitely be of value in materially reducing the harmful vortex-shedding effects of the truss chords. Adequate resistance to torsional and vertical oscillations can, however, be designed into a structure without the use of such roadway slots.

The value of this intensive and comprehensive research will be demonstrated in many of the large bridges that will undoubtedly be built in this country during the next fifty years. The expenditures to which the Public Roads Administration and other agencies have so liberally contributed will thus be fully justified. The resulting information developed by the program will be of inestimable value for the design of suspension bridges in general, even though further extended research may be indicated as new problems present themselves. Nevertheless, it can be confidently stated that we now possess information which makes it possible to design safe, efficient and economical suspension bridges of any feasible span length.

AN ARTICLE TO MOLD THE FUTURE

Longer Concrete Girders? Use a Hollow Box

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WHOEVER DEALS WITH CONCRETE speedily learns that it is heavy. The bridge designer, particularly, who seeks to build long spans, is keenly aware of this fact. For whatever shape or form he may choose, it is the "150 lb. per cu.ft." that finally sets the limits to span length. A point is reached where the work and cost of carrying the concrete itself, apart from other loads, becomes too great.

A challenging problem of the future for concrete girders is to extend that point—economically to justify longer spans, and to build some of the shorter spans more efficiently. By good fortune, the solution is at hand, tested in Europe, but barely tried in the United States: Use a beam section in the form of a hollow box.

Today the T-beam is the dominant form of member used in concrete bridges for either beams or girders. It makes use of the roadway slab for its flange, beneath which is a single, individual stem or web. In the bottom of this stem the main reinforcement is concentrated.

The T-beam is essentially a clean, simple member, both to form and to build, and for certain spans it is preeminently well adapted. It possesses ample flange width for compressive stresses at midspan, and is, therefore, at its best where such stresses govern. Where continuity prevails, however, and compressive stresses develop in the web, as at the supports of continuous beams or rigid frames, it is only the stem itself, perhaps assisted by compressive reinforcement, that must provide the necessary resistance.

It depends upon the spans, loads, dimensions of the beam, etc., whether this fact means much or little, but in the case of long spans it is "*b*", the thickness of the stem, that determines the number of layers of reinforcing bars at midspan, and the effective depth and dead weight there. At the supports it is again this thickness of the beam that establishes its moment-resisting capacity. The curved, generally parabolic, soffit of continuous longer-span T-beams, yielding minimum depth at mid-span, maximum at haunch, is the logical adaptation of the T-beam to stress. Still, that is not an economical section, and its disadvantages grow as span length is increased.

The writer has read of a T-beam of 234.5 ft. in a bridge in Sweden in which the stem—over 22 ft. deep at the support—is slightly enlarged into a rudimentary flange at the bottom. In this country, in Mendocino County, Calif. there are some T-beam spans of 120 ft. Generally, however, in the United States T-beams are employed in spans below 100 ft. Beyond that, except in arches, concrete is replaced by structural steel.

Structural advantages of box-sections

So, for those who desire to use concrete, some other form of section is required if longer girder spans are to be built. The hollow box is the answer. Such girders or beams may be single or multi-celled, and they may be used advantageously and economically for spans ranging from 50 to 250 ft. or more. Made up of slab and wall sections 5 to 6 in. or more in thickness and thoroughly integrated by interior transverse diaphragms, they offer a number of outstanding advantages:

1. Minimum section and minimum weight in the midspan zone where every pound has greater leverage about the supports than pounds do elsewhere in the span.
2. Room for widespread, uncrowded distribution of the tension steel, generally in a single layer, assuring maximum lever arm of resisting couple.
3. Ample compression flange width at supports of continuous beams and rigid frames.

4. Ready adaptability to changes of web and flange thickness.

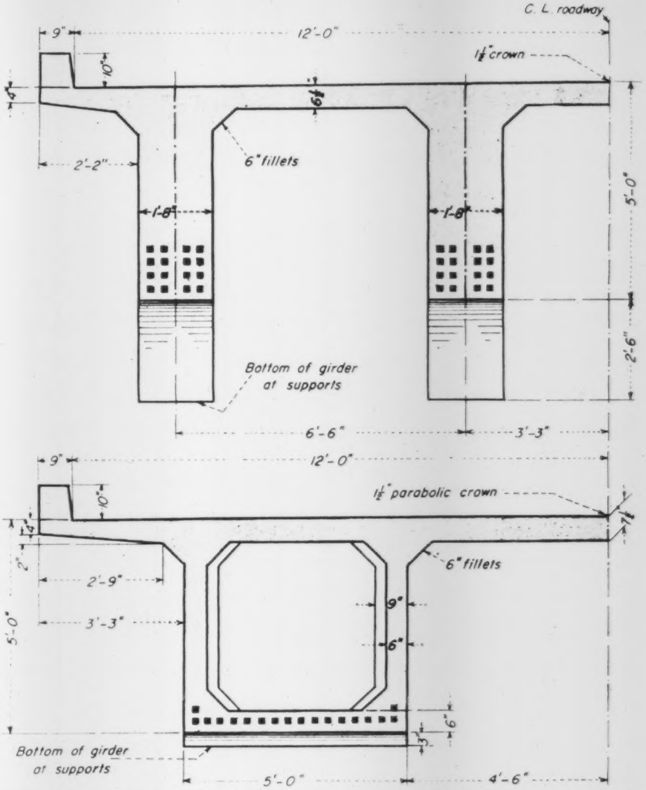
5. Very great torsional strength in the single-walled form; much greater than that afforded by single-webbed beams connected by occasional diaphragms.

6. In the multi-celled form, due to the complete integration achieved, probably the greatest strength, both longitudinal and transverse, that can normally be developed in any bridge deck of beams and girders.

Good appearance and economy

To these structural advantages must be added the pronounced architectural advantage that box sections possess as a result of size and scale commensurate with span. Viewed from beneath they are broad and massive, and convey the appearance of strength and stability.

Lastly, but no less cogent, is the inherent economy of the box-section. This statement is made with full knowledge of some of the appallingly costly structures of this type that have been built in the past, but also with the further knowledge that good looks, clean lines and simplicity are also to be had and at low cost. There is nothing inherent and automatic about costs, either high or low, but if good judgment is exercised in span layouts, which take fullest advantage of the site, and if the design is developed with a sustained purpose to create a bridge that a contractor can build easily and well, "then it must follow as the night the day" that costs will be reasonable and everyone will be happy.



FOR A 100-FT SPAN box and T-sections compare like this on a half roadway width. Depth is same at midspan, but depth of T's increase 50 percent at supports. Box offers economy in material, easier forming, and high torsional strength.

Facts about design

Probably the best approach to the design of box-girders is to read University of Illinois Engineering Experiment Station Bulletin No. 277 "The Strength of Monolithic Concrete Walls." If not that, read BMS 61 of the National Bureau of Standards, "Structural Properties of Two Non-Reinforced Monolithic Concrete Wall Constructions." Therein it will be found that unreinforced concrete test panels 8 ft. 3 in. high, 6 in. thick, made of 2450-lb. concrete sustained, at failure, an average load of 172,000 lb. per foot, with the load applied not axially but eccentrically, 2 in. in from one face of the wall. Knowledge of such facts assures equanimity when filleted box-girder webs of lesser height, held top and bottom by slabs with which they are integrally reinforced, are made 5 and 6 in. thick in the midspan reaches where shear has its lowest values.

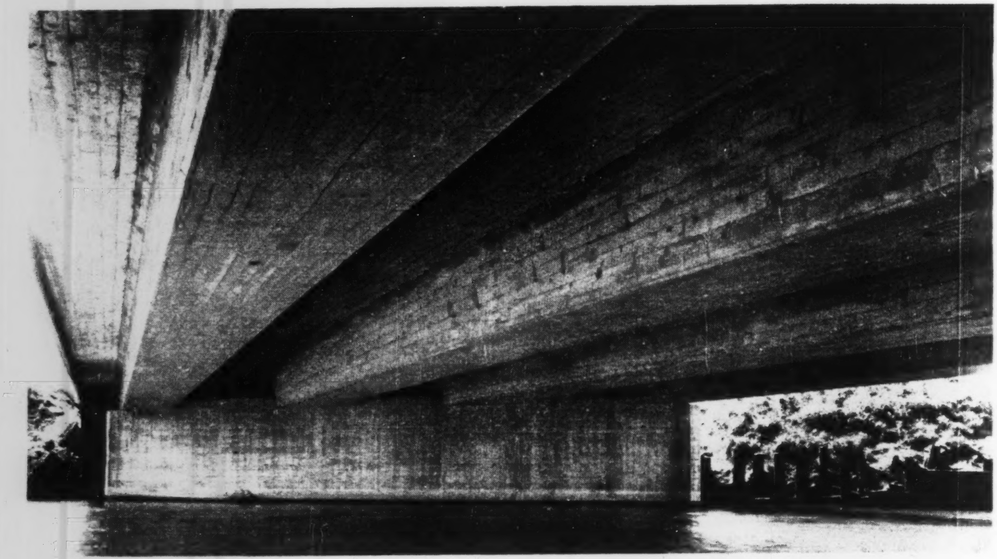
Another basic consideration it is well to have in mind is the stiffness and rigidity that inheres in a hollow section, the relative position of whose webs and flanges is maintained fixed by interior diaphragms that are integral with them and are spaced at frequent intervals. To deform such a rectangle appreciably, to shorten one diagonal and elongate the other by the loads that bridges present, is not easy of accomplishment.

Actually, the diaphragm-stiffened box-section is a member unlike any other that has commonly been used in bridge decks, and possesses much greater strength and stiffness. For that reason there is no point in automatically applying to it the rules that have governed T-beam construction, such as no web less than 15 in. thick and no cross-web less than 10 in. thick. To apply such rules defeats the very purpose of hollow-section construction, which is to minimize dead weight. Moreover, they are wholly unnecessary.

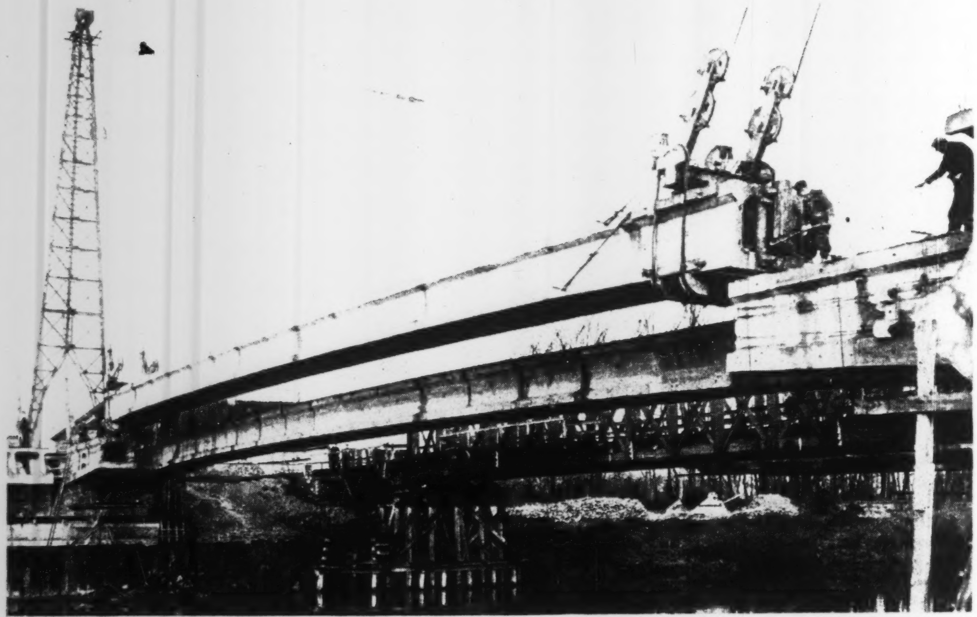
As for the design of box-girders there are no peculiarities, unless it be in assuming the extent of effective flange width. Considering the longer span length, which these girders generally have, and the wide-spread distribution of stress, which is basic in natural economy, it has always been the writer's practice to assume that the full flange area, top and bottom, is effective in carrying stress. Perhaps, at times, this has involved transgression of standard bridge specifications, which limit effective flange area to 6 times the slab thickness on either side of the web. But misgivings, if any, have always been allayed by asking the questions, "What of it? What sense is there in such a limitation?" None being discernible, the restriction has been ignored with no untoward consequences.

Another design assumption is that the webs are so connected by diaphragms, slabs and reinforcement that

Concrete Box Girders Can Provide:



. . . NEW LOOK compounded of massive elements and straight lines, as achieved in 130-ft. span Logan Street Bridge at Renton, Washington, and . . .



. . . LIGHT WEIGHT, which is illustrated by the 180-ft. span Pont de Luzancy over the Marne in France. The precast section being lifted weighs 90 tons, but it is 124 ft. long.

shears divide equally between them. Implicit in this assumption is the further one that these conditions be realized. A diaphragm spacing 5 to 6 times the depth of the girder appears to be quite satisfactory and to yield desired results.

Very helpful assumptions in the design calculations of concrete stress are that stress is uniform from top to bottom of the compression flange and that compressive stresses in the webs will be ignored. The resistive couple of the box-section then has as its lever arm (its "*jd*") the center to center distance between the top and bottom slabs of the box.

No grave apprehensions need be caused by this assumption so long as permissible maximum stresses for bridges remain as they are today—one-half to three-quarters of Joint Committee or American Concrete Institute values. Just why the design of concrete bridges should be regarded as the desperately dangerous matter that standard bridge specifications imply it is, is far from clear.

In general, it will be found that with constant-depth sections and continuity, a depth one-twentieth of the span will work out satisfactorily. This can be reduced where necessary, at the price of increased reinforcement and increased camber.

As with all other types of structure, box-girder spans require cambering. It will be found that an allowance of 1/8 in. for each 10 ft. of interior span and 3/16 in. for each 10 ft. of end span will not depart far from the desired grade line in the case of normal, constant-depth sections.

About ten years ago an unusually shallow box-girder bridge was built with spans as follows: 25-ft. cantilever, 72 ft., 73 ft., 100 ft., 35-ft. cantilever. An expansion joint was provided about the middle of the 73-ft. span. After completion of the bridge, the deck sagged badly. There were no cracks to be seen, and the concrete was of excellent quality. It was puzzling and baffling to everyone who looked at it. Then it was concluded that there was something mysteriously malign connected with box-girders. Finally, however, a great light dawned: it was found that the camber diagram, designed, checked and then again checked and finally approved, called for cambers in the three spans of 3/16 in., 1/8 in. and 7/8 in. It makes a great difference if adequate camber is or is not provided.

A further point deserves mention. Cantilever ends are frequently advantageous in minimizing the size and cost of abutment structures. They are, however, sensitive to temperature changes in the roadway slab of the adjoining span, and will swing through an arc of half an inch or more, depending upon the special conditions obtaining. It is well, therefore, to employ a short transition slab span between the end of the cantilever and the point of unchanging elevation to avoid an abrupt discontinuity of roadway surface.

Economical to build

When it comes to construction considerations the great value of the simple formwork required for box girders is immediately impressive. Angles of 90 and 45 deg. between concrete surfaces are the easiest to form, and will always be found most economical. It is quite possible so to design the bridge that its required carpentry is that of a cabinet maker, but let no one think that low costs are to be achieved by such means.

As standard as domes upon state capitol buildings are the curving lines of variable-depth girders in concrete bridges in America. Yet, as has been so ably and extensively demonstrated by the bridge division of the California Highway Department, very fine effects are achieved by maintaining girder depths constant and uniform from end to end of the structure, and setting back the columns so that the eye follows the soffit line across the bridge swiftly without interruption.

This effect is to be found with steel girders of constant depth. It is seen in the Saco River bridge on the Maine Turnpike, which received the Class II, 1947 beauty award of the American Institute of Steel Construction, and in the Old Alfred Road underpass on that same highway, which received the Class III award. It adapts with particular nicety to concrete box girders, for beam and girder sides of constant depth gladden the heart of every intelligent contractor.

Two other points regarding forms should be mentioned. Changes in the thickness of the girder webs can be made by gradually tapering them, or can be made by small abrupt offsets. The former way assures constantly changing dimension between the webs and, therefore, changing core form dimension. The abrupt offsets give a series of constant dimensions and easier carpentry. The gradual transition in web thickness is structurally better than offsets, but since the difference is of the most trivial importance in its effect upon the performance, it can be ignored.

The other point concerns core forms, which generally are to be left in place for reasons of economy. Core forms should be tight and sufficiently strong to withstand the pressure of web concrete placed around them. They must be anchored against displacement, vertical or horizontal. Beyond meeting these conditions, the contractor should be left free to build them of the lowest-cost materials and with the lowest-cost carpentry he can obtain. There is no point in requiring the same high quality of interior finish that is specified for the exterior.

Some examples

Reference has been made to European use of the box-section in concrete bridges. One of the most notable examples is the Waterloo Bridge across the Thames in London. This is one of the city's principal bridges and was built to replace the old 7-span stone arch, which was constructed shortly after and in commemoration of the victory of Waterloo. The new bridge has a central span of 253 ft. with two 250-ft. spans at either end. It is 80 ft. wide.

The longest concrete girder span known to the writer is the Villeneuve-St. George Bridge across the Seine in France. It is a box-girder structure of three spans: 128 ft., 256 ft., 128 ft. It has two 9-ft. sidewalks and a 28-ft. roadway.

Another European box-girder is the recently constructed Pont de Luzancy across the Marne. Its span is a mere 180 ft., but its construction of precast sections—there are 3 individual main girders—made and assembled on one bank, connected by prestressed reinforcement, and then drawn forward over the river by a construction cableway, gives it the half-incredible novelty expected in French engineering.

The Logan Street box girder bridge across the Cedar River at Renton, Wash., a few miles south of Seattle, is shown in the views at the head of this article as well as on the preceding page. Its main span is 130 ft. and there are 35-ft. cantilever ends. The roadway is 48 ft. and there are two 6-ft. sidewalks. Loading is H20, S16, AASHO 44. Its overall depth is 5 ft.

The bridge crosses the river at a skew of 33 deg. 30 min. Because of this skew individual girders were employed. There are four of them, each 5 ft. wide, spaced 14 ft. on centers, and they are crowded with steel at midspan. Each has four 5-in. interior diaphragms, spaced 28 ft. 6 in. o.c. symmetrically about midspan. All warping in the deck was made to occur in the relatively flexible roadway slab by the omission of any webs or diaphragms between the girders except at the outer ends of the cantilevers. The American Pile Driving Co., Everett, Wash., was the contractor.

AN ARTICLE TO MOLD THE FUTURE

Water from Wastes: Concepts and Costs

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THE VERY THOUGHT of consuming water that has been directly reclaimed from municipal sewage and industrial wastes is repugnant. Yet thousands of people daily drink treated water that has been polluted with such wastes. This contradictory condition is one that requires close examination in view of the rising demand for water and increasing costs for developing acceptable distant water supply projects.

Since sewage-polluted rivers and lakes are now being used as sources of water supply, the concept of water reclamation from sewage and industrial waste is not radically new. The effluent from tens of thousands of septic tanks and cesspools throughout the country has been leaching into underground strata for years. Whenever water is pumped from aquifers underlying septic tanks or cesspools, there can be no doubt that much of the liquid that reaches these disposal tanks eventually finds its way back into the water system.

Esthetic and health considerations

Solely on esthetic grounds—without reference to health implications—public prejudice prevents direct re-use of water reclaimed from municipal sewage and industrial wastes for domestic purposes—even though the standard of the reclaimed water complies in all respects with that for potable water.

By a universal twist of reasoning, this prejudice does not exist if the reclaimed water is purified by what is termed a "natural" process. The public does not object to reclaimed water mingled with other potable supplies, or to water sources into which municipal sewage and industrial wastes are dumped.

From this quirk, two essentials for unrestricted use of the reclamation plant output may be postulated: Reclaimed water must undergo some "natural" purification, plus blending either before or after reclamation.

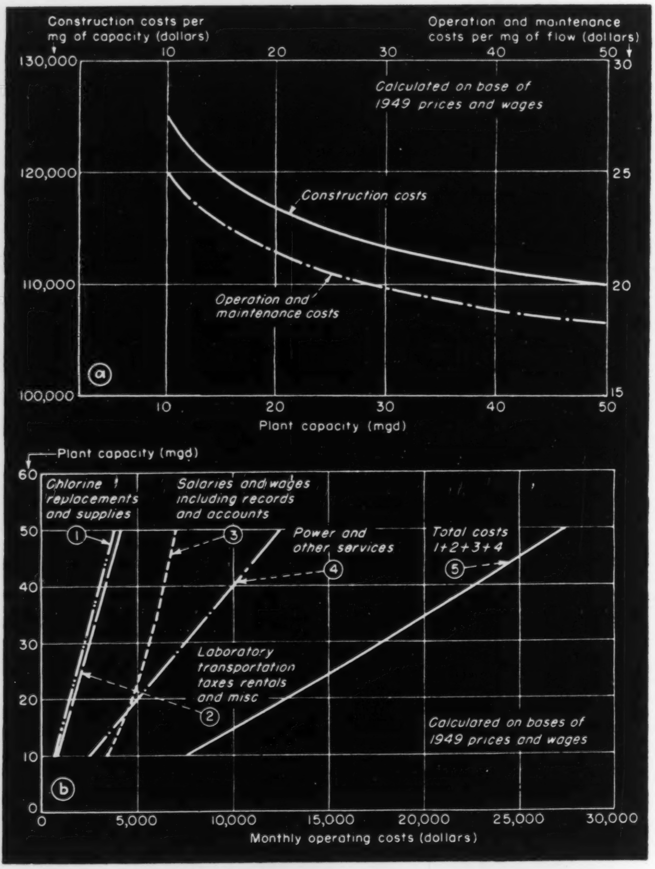

Fig. 1. **CONSTRUCTION AND OPERATING COSTS for water-reclamation plants using sewage and industrial wastes as the "raw material." For plant capacities from 10 to 50 mgd., monthly operating costs range from $7,500 to $27,500.**

If the reclaimed product is to be accepted for unrestricted use, certain conditions must be observed in operating a sewage-water reclamation plant. Among these are:

(1) The plant must be completely separate from sewerage facilities serving an area. It must not be relied on to dispose of wastes.

If separation of wastes is not carried out in design, the reclamation facility must take and dispose of total inflow without being able to reject any or all of undesirable wastes. The plant must incorporate all processes required for disposal of sewage. Its location will be dictated by geographical restrictions and limitations imposed on a sewage treatment plant.

(2) Sewage disposal facilities should

be capable of handling the entire water reclamation plant flow. This requirement stems from the fact that production of water may be interrupted at any time by arrival of undesirable wastes that would necessitate diverting the entire flow to the sewers and possibly emptying the entire contents of the reclamation plant into the sewers.

(3) The plant should be located so that the municipal sewage supply is of a chemical composition that will facilitate production of an acceptable, satisfactory-quality water.

(4) Spreading areas should be available within reasonable distances from the plant where plant effluent may be distributed on infiltration beds, percolate through the soil and reach underground storage. From underground reservoirs it may then be pumped for re-use.

The necessity for spreading plant effluent on open beds operated as slow sand filters calls for production of a well-oxidized, highly purified water so that odor nuisance may be eliminated.

Factors governing plant location

Selection of sewage of satisfactory quality, availability of an ample-capacity sewerage system and recognition of the nature of the reclaiming process will permit location of reclamation projects without consideration of the restrictive rules that govern sewage works sites.

A complete reclamation plant designed to produce water for unrestricted use might include the primary settling, aeration and final sedimentation facilities of an activated-sludge plant plus essential appurtenances and auxiliary equipment needed for proper operation.

Facilities for treatment and disposal of sewage sludge would not be a part of the reclamation plant. Sludge would be returned to the sewers from which the raw-water supply had been taken.

The cost of construction as well as of operation and maintenance of a complete water-reclamation plant with capacities from 10-50 mgd. may be estimated from Fig. 1(a). A detailed breakdown of operating costs is given in (b).

Return effluent to ground water

Additionally, it seems necessary to find some method of returning plant effluent to ground-water storage so that it may mingle with other waters before re-use. It appears likely that the only practical methods of return is the spreading of effluent on natural sand beds by the fill-and-draw system. Based upon long-period operation of sand beds for flood-water dispersal (Fig. 2), effluent spreading on natural filters would cost about two dollars per million gallons.

A number of investigators have suggested that reclaimed effluent be returned to underground strata through wells. An analysis of unfiltered effluent—particularly so as to grease and organic matter content—will quickly disclose that this method of return will not be practical. Even with all the best-functioning oxidation processes excepting filtration, the plant effluent carries sufficient organic matter in suspension to clog the interstices of coarsest sands. Ample operating experience is available to confirm the results forecast by analysis.

Purification through leaching

Experiments have been conducted to determine the purification efficiency of natural sand beds operated as slow sand filters. When well-oxidized effluent from sewage treatment works was applied to a spreading area at the rate of 0.5 cfs. per wetted acre during a 14-day test, no pollution (zero coliform index) as well as aerobic conditions were found at 4 to 7-ft. depths below the ground surface. A mechanical analysis of sands in the percolation bed is given in Fig. 3.

As a result of these tests, it is concluded that, under similar conditions, a natural sand bed may be expected to operate successfully at an equivalent rate on a two-week cycle. The cycle would include percolation for about a week followed by drying out, aerating and complete reconditioning of the surface of the bed.

Raw and treated municipal sewage is directly used in agriculture, particularly in arid western states. Factors influencing this use are: No available diluting water; need of irrigation for crop culture; sufficient isolation to prevent nuisance; and economy.

If the agricultural demand for water is relied upon for final disposal of sewage or plant effluent, seasonal demand for irrigating waters should be taken into account. This consideration, unfortunately, is often overlooked.

Effect of seasonal demand

When seasonal demand is considered, one of two circumstances prevails: The area to be irrigated must be much larger than that needed for crop culture to accommodate wet, off-season flow; or crop-culture lands must be waterlogged most of the time, irrigation being practiced without consideration of agricultural demands and limitations.

The proponent of agricultural use of reclaimed water must recognize that agricultural land cannot be fully utilized unless sewage disposal depends on factors other than irrigation. This limitation underscores the basic assumption that reclamation of water for efficient agricultural use must be completely divorced from the whole issue of sewage disposal. Coupling the two activities together can only result in either inefficient use of land or improper disposal of sewage. Quite universally, it is the former.

Water reclaimed from municipal sewage has an application in industry. Direct re-use of effluent from any sewage-treatment step for this pur-

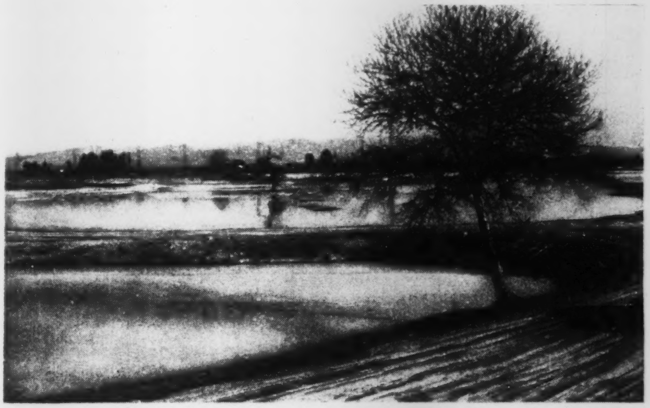

Fig. 2. SPREADING GROUNDS—like Los Angeles County Rio Hondo flood-water percolating beds—are an essential step in sewage-water reclamation to overcome public prejudice against direct re-use of reclaimed water.

pose is perfectly appropriate under certain circumstances. Use of the reclaimed effluent does not constitute a means of sewage disposal.

Success of the industrial-water reclamation system is dependent upon the existence of a sewerage system into which used reclaimed water, or any part of it, may be discharged. It is of no concern whether the sewerage system constitutes a series of pipelines, sewage treatment plants, a river, lake or the ocean.

Factors limiting agricultural use

Irrigation water is considered of excellent quality when it contains (1) less than 175 ppm. of dissolved solids. (2) not more than 50 percent sodium as indicated by the equation

$$\text{Percent Sodium} = \frac{\text{Sodium} \times 100}{\text{Calcium} + \text{magnesium} + \text{sodium} + \text{potassium}}\ ; \text{ and}$$

(3) 0.33 to 1.0 ppm. boron, depending on the use of irrigating water for boron-sensitive or-tolerant plants. From excellent to unsuitable irrigation waters are graduated in fairly equal increments to fit the descriptive terms of "good," "permissible," doubtful" and "unsuitable." Unsuitable water contains more than 2,100 ppm. dissolved solids, more than 80 percent sodium and 1.25-3.75 ppm. boron.

It is desirable, in general, that sulfate and chloride content of irrigation water be less than 200 and 150 ppm., respectively. Although irrigation waters with three or more times these concentrations and of unsuitable quality are in use, their continued application will damage soil characteristics and evenutally destroy the tilth of soils.

Grease in sewage used for irrigation creates an acid condition in the soil in time that will require liming for neutralization.

Public health considerations demand that water reclaimed from sewage and used without restriction for irrigation must comply with the bacterial-quality standards for potable supplies. If this standard is not met, the reclaimed water may be used only to irrigate nursery stock, cotton, stock feed and some of the grains. Ditches and pipes for conveying sub-standard waters must be entirely separate from those distributing waters of acceptable quality. Berry bushes and orchards may not be irrigated with sub-standard water during the ripening season.

Limiting factors for industrial use

The quality and character of industrial water supplies will depend upon specific processing needs. Industrial uses of water vary so widely that industrial plants generally are located either where water of a satisfactory quality is available or where ample amounts of economically treatable water can be obtained.

Direct use of reclaimed-sewage water in industry is restricted by public health considerations to those processes where there can be no contact between the reclaimed water and humans or processed food. It is likely that specifications for cooling and boiler-feed water will detail quality requirements as well as degree of treatment required when sewage is the water source for an industrial supply.

Some industrial wastes render sewage unfit for reclamation or re-use. Among these are: Salts in high concentrations; some aromatic compounds, such as phenols; and certain petroleum by-products.

Such contaminants must be kept out of the raw-water supply for reclamation plants. Discharge of the undesirable contaminants into the supply sewers will preclude the possibility of water reclamation. Trunk sewer systems that serve either concentrated or widely scattered industries should be designed to permit exclusion of objectionable material from that portion of the sewage flow being delivered to the reclamation plant.

Sewage from controlled areas

Water reclamation from municipal sewage should not be confused with that from wastes discharged from individual industries, institutions or completely controlled areas. Typical of restricted-flow reclamation are the plants at the Kaiser Steel Works, Fontana, Calif., the Golden Gate Park in San Francisco and the El Tovar Lodge at the Grand Canyon of the Colorado in Arizona.

At such restricted-flow plants, a few of the operating troubles characteristic of municipal-sewage reclamation are encountered. Water-reclamation plants to serve limited areas, therefore, may be designed with complete assurance that they will perform equally well for sewage disposal, both types of processing being combined into a single plant.

Summarizing, all of the "props" are at hand for safe reclamation of water for unrestricted use from municipal sewage, provided a natural purification step is a part of the reclaiming process. Percolation beds can provide this natural step.

With a better-than-average oxidized effluent applied to natural percolation beds operated as slow sand filters, it is difficult to visualize how the operation can fail to produce the desired results. Intermediate grades of water for special uses may be obtained by limiting the reclamation process to primary steps.

Water-reclamation plants using municipal sewage and industrial wastes as the "raw material" must be capable of producing an all-purpose water to be wholly successful. If this end is not achieved, processing limitations will render the activity unsafe or experimental. The process must be "cut and dried"—accident-proof and fool-proof. It must admit of no possibility of failure. Every factor that might lead to use of unsuitable water must be eliminated. The water-reclamation process must be judged by the constant—not average—quality of its output.

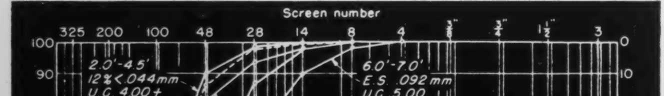

Fig. 3. SIEVE ANALYSIS of natural sand having a percolation rate of 0.5 cfs. per wetted area. No pollution and aerobic conditions were found at 4-7 ft. depths.

Better Concrete for Our Future Dams

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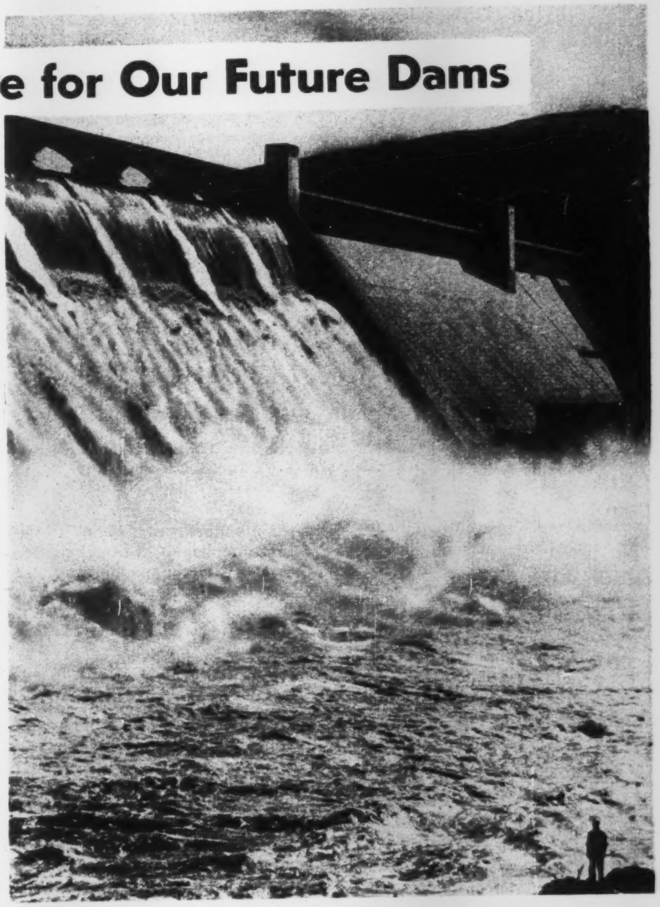


CAN WE AFFORD to build such structures with concrete much short of the ideal?

THE NEXT HALF CENTURY poses a particular challenge to the concrete dam builder. This is so because more and tougher-to-build dams will be required, and because, despite some notable advances in knowledge, the dam concrete of the past has been far from ideal. Some of it has been of poor quality; much of it misused or misunderstood; all of it has been too costly to place and to cure.

Two courses of action thus beckon our efforts and demand our attention: (1) To use the knowledge that we now have, completely and intelligently to make the best adaptation practicable of concrete as we now know it; and (2) to seek the more logical approach, i.e., the development of concrete having the particular properties desired for mass construction. The first course of action is the only recourse for the immediate future; the second holds vastly greater promise for lasting benefit and the ultimate solution of our mass concrete problems.

Bearing on the second course of action, it may be noted that we are still evaluating the load-carrying capacity of concrete on the assumption that it is a perfectly elastic material, and on the further assumption of uniaxial loadings. This practice is still followed in spite of the fact that we know concrete behaves plastically, relieving highly stressed portions of a structure by transfer of stress to lower stressed areas, and that stress adjustments occur through long-time creep effects.

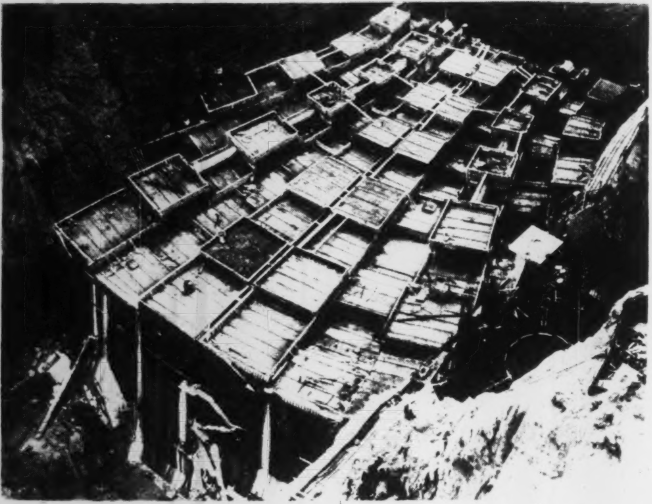
It is also well known that uniaxial loading seldom occurs in an actual structure and that the loading conditions are usually either biaxial or triaxial combinations. This means that present methods for computing the load-carrying capacity of structures give values that are too low and factors of safety that are in reality little more than factors of ignorance.

The kind of concrete needed for low-cost concrete dam construction is one that would have low thermal volume change, a high degree of plasticity and extensibility, a high degree of impermeability, and sufficient strength to carry the loads without excessive increase in dimensions of the section. Frankly, we don't know how to make this kind of concrete in the light of present-day knowledge and with available materials and equipment, and existing construction methods.

This brings us back to the first course of action, i.e., the development of better and cheaper ways of adapting concrete as we now know it to the particular requirements of concrete dam construction.

The volume change problem

The troublesome temperature rise and thermal shrinkage of concrete, when used for building dams, have given rise to most of our mass concrete problems because the heat generated during hydration must be dissipated or removed. As the temperature is reduced, the volume shrinks. This shrinkage must be carefully con-



COSTLY CONSTRUCTION EXPEDIENTS, such as the use of a multiplicity of joints, are required to adapt present-day concrete to dam construction.

trolled in order to avoid serious cracking. Ingenious expedients have been devised to control this volume change and cracking:

1. Consruction procedures
    a. Contraction joints
    b. Artificial cooling of concrete in place
    c. Precooling of concrete
    d. Keyed joints
    e. Grout stops and water stops
    f. Contraction joint grouting
    g. Limits on construction lifts
    h. Slots
2. Low-heat cement
3. Pozzolans
4. Sand cement
5. Air-entraining agents
6. Rich face concrete

Some of the above described expedients add materially to the cost of building concrete dams, while others effect substantial savings in their design and construction.

Uniformity of top importance

Building a concrete dam is essentially a mass production manufacturing operation; therefore, the control of uniformity of the concrete from batch to batch is of paramount importance. Even a small concrete dam requires 50,000 4-cu. yd. batches, each containing on the order of 20 to 25 trillion particles. If each batch of concrete could be made with exactly the same number of each size particles, obviously there would be no field control problem. Control of uniformity starts with the manufacture, processing or preparation of the ingredient materials.

Cement. The uniformity of cement under a given specification leaves much to be desired. Raw materials vary considerably which, together with the manufacturing processes employed in different plants, cause wide variations in the properties of the finished cements.

Even the cement supplied from a single plant will vary through wide limits from time to time. Consequently, the production of a uniform product from a given plant requires every precaution and the application of every known control measure throughout the quarrying, blending, grinding, burning, and handling operations.

Aggregates. In the production of uniform aggregates for concrete dams it is important to control the grading within narrow limits of a predetermined satisfactory grading curve. If the aggregate is manufactured by crushing, the type of equipment and the sequence of operations to produce individual particles of the desired cubical shape are important. If the aggregate material is natural sand and gravel; the material must be cleaned, separated, classified and recombined in a manner such that the final grading will be uniformly near an ideal grading curve.

The control of the moisture content of fine and coarse aggregate requires a sufficient period of time in storage to permit drainage to a stable moisture condition, otherwise the control of the concrete consistency is difficult. To obtain a semblance of uniformity of aggregate grading, it is necessary that it be separated into size fractions of sufficiently narrow range to minimize segregation. Separated aggregates having minimum amounts of undersize can be obtained most effectively by finish screening at the batching plant. The several size fractions are batched separately to improve the uniformity of aggregate grading in the finished concrete.

Admixtures. Mass concrete of today frequently contains admixtures such as air-entraining agents and pozzolanic materials. These materials are subject to variations in physical and chemical properties depending upon the source of raw materials and the procedures required in their manufacture. This in turn requires constant testing to determine quality and uniformity. Entrained air must be controlled to the desired percentage of the *concrete in place*, which requires allowance for many influencing factors between mixer and forms. Foolproof methods are required to prevent substitution of pozzolan for cement and vice versa.

Concrete. If we succeed in controlling the uniformity and quality of the separate ingredient materials, then the control of the uniformity of the concrete is made much easier. Nevertheless, constant inspection and testing is required. The importance of effective field control must be fully recognized and supported by everyone connected with the work from top management on down.

Great strides have been made during the past two decades in the development of efficient and accurate batching equipment. Automatically controlled weigh batchers with complete recording equipment are now available and generally required in dam construction. This eliminates the human element in batching operations, provides a record of each material entering each batch of concrete, and, in combination with consistency meters, provides also a record of the consistency of each batch of concrete. These records have proved invaluable for control purposes because an operator can immediately detect any irregularity in the composition of the concrete as it is batched.

Concrete mixers have not advanced in parallel with batching equipment, and mixers now available leave much to be desired in combining the separate materials to a uniformly mixed product. Quite recently the importance of such factors as charging sequence, mixer blading arrangement and mixer operations have been recognized, resulting in increased mixing efficiency.

The most important factor in the control of the mixing operation is the control of the water content, because the water-cement ratio is the best criterion of concrete quality. Consequently, if the cement and water content are accurately controlled to provide uniform consistency from batch to batch, it may be assumed that the quality of the freshly mixed concrete will also be uniform. Since an appreciable portion of the mixing water for each batch is contained as free water in the sand and aggregate, the control of the moisture content of the aggregates to a uniform percentage is important in the control of the water-cement ratio and consistency.

The generally accepted method of transporting mass concrete for dams is by large straight-sided bottom dump buckets handled by cableway or from trestles. Buckets are now available which can be controlled during the dumping operation to deposit the concrete in layers not exceeding 18 inches.

Efficient internal vibrators in turn make it possible to consolidate the fresh concrete in place with minimum slump. There is no excuse for cold joints or improperly prepared construction joints with the modern equipment that is now available for dam construction. Chuting and conveyor-belt-handling of fresh concrete are no longer recognized as acceptable construction methods.

The final step in building a uniform concrete dam is to see that the hardened concrete receives thorough moist curing for the specified minimum period of time. Here again recent developments in soaker hose and sprinkler heads have greatly facilitated this operation.

Materials and proportions

In the light of present knowledge, mass concrete mixes are designed for minimum cement and water contents consistent with the strength requirements, minimum consistency (0-to 1½-in. slump), low heat of hydration and volume change, and high crack resistance. The materials used in making mass concrete largely control these desired characteristics.

Portland Cement. While Type I portland cement has been used to build many concrete dams, very large dams could not be built with ordinary cement at present-day construction rates without serious cracking. The need for lower-heat cements for dam construction led to the development, starting about 1930, of "low-heat" or Type IV portland cement. Low-heat cement is produced by reducing the tricalcium aluminate and tricalcium silicate compounds and increasing the dicalcium silicate.

In reducing the temperature rise in mass concrete and the attendant shrinkage due to cooling, low-heat cement is beneficial only in combination with artificial cooling or with undesirably long periods of exposure between lifts. The slow rate of early heat generation makes artificial cooling to reduce maximum temperature practicable. Without artificial cooling or some other expedient, it is preferable to use Type II cement having a more rapid rate of early heat generation and dissipation.

Both Type IV and Type II cements, in the order named, improve the extensibility or crack resistance of concrete and otherwise improve its general quality as a result of the reduced C_3A content, which is the least desirable compound in portland cement.

Cements for mass concrete should be ground to 1600 to 1800 specific surface to reduce bleeding, improve workability and uniformity and to insure adequate early strength for form removal.

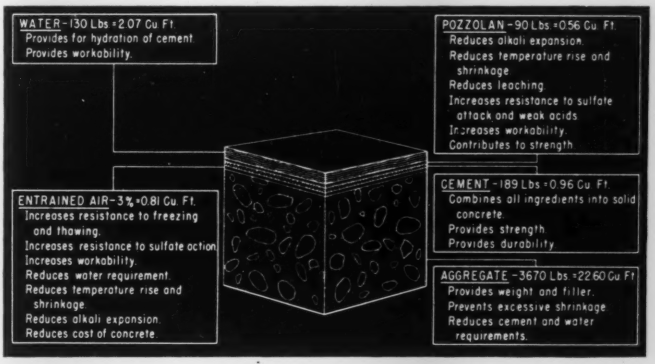
Sand-Cement. Arrowrock Dam (Idaho) and Elephant Butte Dam (New Mexico) were two of the first large dams to be built. The portland cement for these two dams was obtained by intergrinding about equal parts of coarse ground cement and granite and sandstone at the jobs. This was an economy measure but it also served to reduce temperature rise, thermal shrinkage and cracking. Strengths were low but adequate.

After more than 30 years of service both of these dams are exceptionally crack-free and watertight. Some disintegration has occurred at the downstream faces, which could have been avoided by richer face mixes.

The ground sandstone and granite possessed no cementing qualities, and sand cement is not recommended for dam construction in view of the availability of siliceous materials that do have cementing value.

Portland-Pozzolan Cement. Portland cement clinker interground with pozzolanic materials at the mill have been used on a number of mass concrete projects, most notably Bonneville Dam and certain of the San Francisco-Oakland Bay Bridge piers. The pozzolans used include calcined shale, calcined clay, blast furnace slag and volcanic tufa. All of these installations have proved satisfactory.

Exhaustive tests carried out by many organizations during the past 20 years have conclusively demonstrated the superior qualities of portland-pozzolan concrete for mass construction. There are, however, but few plants equipped to produce finished portland-pozzolan cement which has led to the use of pozzolans separately batched on the job. Pumicites were used in Friant Dam in California and Altus Dam in Oklahoma in the proportions of 20-percent and 35-percent replacements by weight of the portland cement, respectively. Calcined shale is now being used in Davis Dam in Arizona in the proportion of 20-percent replacement. At Hungry Horse Dam in Montana, it is planned to use


WATER-130 Lbs.=2.07 Cu. Ft.
Provides for hydration of cement.
Provides workability.
POZZOLAN-90 Lbs.=0.56 Cu. Ft.
Reduces alkali expansion.
Reduces temperature rise and shrinkage.
Reduces leaching.
Increases resistance to sulfate attack and weak acids.
Increases workability.
Contributes to strength.
ENTRAINED AIR-3%=0.81 Cu. Ft.
Increases resistance to freezing and thawing.
Increases resistance to sulfate action.
Increases workability.
Reduces water requirement.
Reduces temperature rise and shrinkage.
Reduces alkali expansion.
Reduces cost of concrete.
CEMENT-189 Lbs.=0.96 Cu. Ft.
Combines all ingredients into solid concrete.
Provides strength.
Provides durability.
AGGREGATE-3670 Lbs.=22.60 Cu. Ft.
Provides weight and filler.
Prevents excessive shrinkage.
Reduces cement and water requirements.

GOOD DAM CONCRETE. This is what a cubic yard would contain and what each ingredient would contribute.

separately-batched fly ash in proportions yet to be determined, but probably around 33-percent.

When finished portland-pozzolan cements become generally available, it will obviate the necessity of handling a separate material at the job, and greatly facilitate the production of uniform mass concrete.

Pozzolans (of the right kind) in combination with Type II portland cement improve the qualities of concrete for dam construction as follows:

1. Reduce temperature rise
2. Reduce thermal shrinkage
3. Develop early strength slowly but give high ultimate strength
4. Increase watertightness
5. Improve extensibility or crack resistance
6. Increase plasticity or stress adjusting characteristics
7. Reduce drying shrinkage
8. Increase resistance to sulfate attack
9. Reduce dissolution or solubility of paste
10. Reduce water content
11. Improve workability

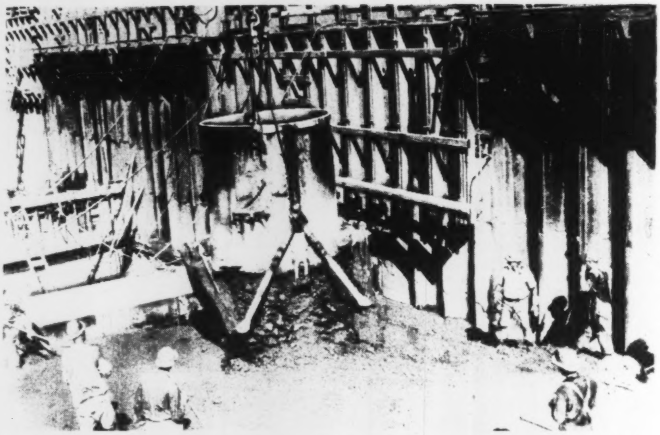
Portland-Natural Cement. The U. S. Engineers are presently employing a portland-natural cement combination in the construction of one of their dams. Tests and experience have shown that such a combination also imparts to mass concrete many of the desired characteristics.

Aggregates. Within the past decade, it has been discovered that certain siliceous constituents of many aggregates react with the alkalies in portland cement to cause expansion of the concrete with attendant severe surface cracking. This expansive cracking is caused by the formation of siliceous gels and the development of osmotic pressure through the cementing matrix, which acts as a semi-pervious membrane. Mass concrete subject to alkali-aggregate reaction deteriorates but little in the interior provided it is sufficiently restrained. However, the excessive surface cracking provides weakened surfaces and an opportunity for deteriorating elements to gain a foothold.

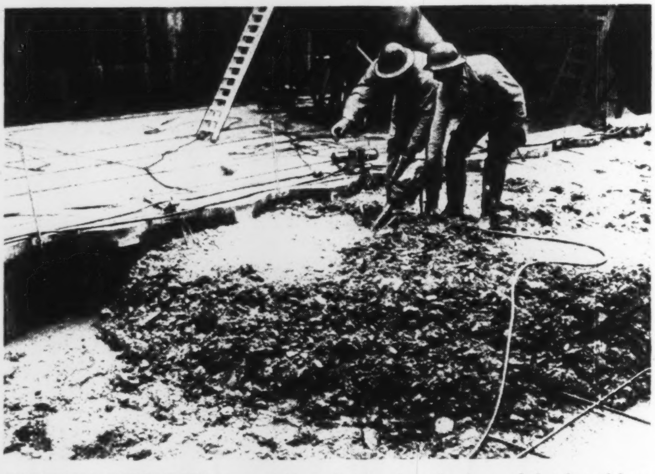
Few, if any, aggregates are inert, either chemically or physically, and procedures have been developed for determining the chemically-active constituents. When reactive aggregates must be used, ameliorative measures can be taken to minimize or eliminate the expansive cracking:

1. The use of low-alkali cements
2. The use of the right kind of pozzolanic materials
3. Air entrainment

THESE THINGS HELP:



STRAIGHT-SIDED BUCKETS that discharge, without segregation, a mix made workable and cohesive by air entrainment and pozzolanic admixtures.



INTERNAL VIBRATORS that quickly melt into place the 4 cu. yd. batches of low-water-content concrete—the kind required in dams.

The alkali-aggregate problem, together with a recognition that surface texture and the type, size and interconnection of pores play controlling parts in determining the concrete-making qualities of an aggregate, has led to new concepts on how to evaluate aggregates. Emphasis is now being given to those concrete-making properties rather than the properties of the aggregate particles as rocks. In judging the suitability of a given aggregate for mass concrete purposes it is recognized that a combination of cement, aggregate and admixtures must be obtained which will be compatible both chemically and physically when combined into concrete.

With a 6-in. maximum size, the coarse aggregate (plus quarter inch) for mass concrete must be separated into four size fractions, which with the sand, makes a total of five sizes of aggregate to be batched. If cement and pozzolan are used separately and an air-entraining agent used, this makes a total, including the water, of nine materials to be batched. If the granular materials alone in a 4-cu. yd. batch of concrete were placed side by side they would form a thin continuous line which would reach to the moon and back, again emphasizing the necessity for rigid control.

Air Entrainment. The most important development in concrete during the past 30 years has been the discovery that the entrainment of minute air bubbles in concrete greatly increases its resistance to freezing and thawing and improves many other qualities. The adaptation of entrained air to mass concrete was inevitable because it constituted a long step toward the ideal concrete for massive construction.

For concrete containing 6-in. aggregate, the optimum percentage of air is 2 to 4 percent. Each percentage of air entrained permits a reduction in water content of from 2 to 4 percent and, for a given W/C ratio and slump, a corresponding decrease in cement content. Other effects of entrained air include:

1. Improved workability
2. About 5 percent loss in strength for each percentage of air
3. Improved handling and finishing qualities
4. Reduced overall costs of concreting operations
5. Reduced unit weight of concrete
6. Reduced temperature rise and thermal shrinkage
7. No loss in watertightness within limits of air content specified
8. No increase in drying shrinkage within limits of air content specified
9. Increased resistance to sulfate attack
10. Reduced alkali-aggregate expansion

Numerous materials will cause air to be entrained in concrete. Such agents vary widely in their effects on the concrete. We understand but little about the effects of size, grading, and spacing of the entrained air bubbles or the inherent nature of the entraining agents on the concrete properties. Hence, the problems to be solved in developing a suitable specification for air entraining agents appear almost beyond solution at the present time.

Construction procedures

In the 1900 era, concrete was better adapted to building dams by the slow construction methods then economically feasible. In 1887 the Crystal Springs Dam in California was built with a very dry mix, hand-rammed in layers 3 in. deep. The fact that it is not so well adapted today is not because the quality of the concrete is lower (it is undoubtedly much higher) but because concrete engineering has not kept up with the demands made upon it by the stepped-up rate of present construction economics. In at least one respect (low-cement content and the use of fine material other than cement) we are back where we were 35 years ago.

Studies of cracking, stress distribution, deflection, leakage and other phenomena have indicated that the design of a concrete mix for dams is not something which can be carried out wholly in the laboratory, in the designing office, or on the drafting board. It is obvious that the engineer must take into account the particular site conditions to which the structure is to be adapted; it is not so obvious that he should also be concerned with the contractor's construction plans, the water diversion scheme, details of the final excavation, sequence of concrete placement operations, climatic conditions, and similar details. Any or all of these factors, however, may have an influence on the stress distribution in the structure and upon the required quality of concrete that is necessary to insure a reasonable margin of safety.

To control temperature rise and thermal shrinkage under present high rates of construction, it is usual practice to remove the heat by circulating coolant through embedded pipe systems spaced 2½ to 5 ft. at similar vertical intervals. Sometimes this is combined or replaced by reducing the initial temperature of the concrete by pre-cooling before it leaves the mixer. Further control of temperature rise is obtained by limits of 2½ to 5 ft. on height of construction lifts with minimum periods of exposure at lift surfaces of 3 to 5 days.

The volume change as the temperature is reduced is controlled by contraction joints, which are usually keyed and add materially to forming costs. These joints in turn require expensive grout pipe systems, grout stops, water stops and eventually grouting to provide a watertight, monolithic structure.

Pronounced irregularities in the foundation may constitute focal points for the formation of cracks, requiring special construction procedures. These may consist of close-spaced cooling pipes to reduce the temperature rise of the concrete; shallow lifts placed at a slow rate; filling depressions and leveling out steps by placing concrete up to the general foundation level and then waiting a considerable period before proceeding with the construction.

If a lift surface has been exposed, for say a month or more, it should be considered as a foundation, and any special placing or cooling precautions which have been taken at the foundation should be repeated there. If the side walls of certain monoliths are to be exposed for a long period, as frequently happens when blocks are left low for river diversion, it may be advisable to install a special arrangement of cooling pipes to reduce the temperature gradient toward the exposed face. Concrete placed in cool weather will develop its strength more slowly, but in the long run it will be better concrete and show fewer cracks than concrete placed during periods of hot weather.

Looking into the future

Probably the ideal dam concrete will never be attained but, certainly, we can progress much further than we have. Also, engineering ingenuity can devise cheaper ways of adapting concrete to dam construction. In one way or another, less costly concrete dams will come or we will build more and more earth structures.

There is much to be learned about portland cement and still more about how to make and use effective pozzolans. Admixtures are in the picture, which not only will entrain air in the proper manner, but also will further reduce water requirements and volume change. We need understanding of the role of aggregates in the sequence of chemical reactions which transform a semi-liquid mass into hard stone.

Most rational design theories, which will take advantage of the true characteristics of concrete as a building material, are already on the horizon. Knowledge is accumulating from actual measurements of stress and strain distributions in dams. Data from triaxial tests of concrete and rock will make possible the use of this knowledge toward a more realistic determination of the quality of concrete required in the interior of dams.

Prepaked concrete is made by consolidating coarse aggregate in place and solidifying by the intrusion, through pipes, of a grout mixture composed of cement, pozzolan, fine sand, admixture and water. It has shown sufficient promise for dam construction that the U. S. Engineers and the Bureau of Reclamation have initiated intensive investigations. Both the material and its use in dams are covered by patents.

The mass concrete problem, and other similar engineering problems, have developed because research and technical advancement have not kept pace with practice. However, engineers are learning to use the technical tools of all sciences more completely and effectively and to seek the aid of their scientist friends.

AN ARTICLE TO MOLD THE FUTURE

New Horizons for Activated Sludge

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ALTHOUGH THE ACTIVATED-sludge process is one of the most useful methods of sewage treatment yet devised, it has not reached the highest possible stage of perfection. There are still many ways in which the process may be refined and improved to bring about economies in construction and operation, and to give better operating results.

The places to look for these improvements are in:

(1) Sedimentation of raw sewage before aeration.

(2) Closer control of sludge age in the aeration systems.

(3) Concentrating excess activated sludge in separate tanks.

(4 & 5) Re-locating effluent troughs and sludge-removal outlets in final settling tanks to take advantage of density currents.

(6) Correlating air supply with abstraction of sewage impurities.

(7) Regularized re-conditioning of air-diffusion media.

(8) Employing "step aeration" to reduce tankage, improve control or handle greater-than-design flows.

(9) Utilizing "modified sewage aeration" processing where complete treatment is not required.

Pre-settling is justified

Because the entire process of sewage treatment—aside from chlorination—concentrates on removing and disposing of materials in the sewage, pre-sedimentation before activated-sludge processing will nearly always be justified. Pre-settling tanks are relatively cheap and, up to a reasonable limitation, remove more material at a lower cost than other device.

Any material not removed by pre-settling must be maintained under air for several days. It then must be disposed of in a much more bulky condition than if it had been settled out in a primary tank.

One advantage of pre-settling is that less of the volatile material useful for gas production is lost.

Sludge activity and settleability

Basically, successful operation of activated-sludge plants depends on control of two essential sludge characteristics—activity and settleability.

Typical activated-sludge floc contains zoogleal bacteria that live and grow under aerobic conditions and have the ability of abstracting dissolved and colloidal material from surrounding liquids. It is through the activity of these bacteria that floc is built up and impurities are removed. Other types of bacteria and microorganisms assist in maintaining the sludge in biological equilibrium.

After the floc is built up, it must be separated from the purified liquid by sedimentation, the success of which depends on quality of sludge floc. Floc must settle readily and at the same time retain the ability of its zoogleal masses to remove impurities. It is unfortunate that the greatest ability to remove impurities sometimes occurs when the sludge exhibits very poor settling qualities.

Observations at well-operated plants show that, with sludge in good condition, only a short period—perhaps 30 minutes—is required for most sewage impurities to attach themselves to the floc. But it is generally true that a mass of activated-sludge solids, representing a weight of at least three times that of the daily load of suspended solids, is continuously recirculated through the aeration system. With 4-6 hr. detention, it is apparent that the major part of the aeration period is devoted to maintaining sludge in good condition.

Sludge age the quality criterion

The fact that such a long detention of sludge masses is essential for successful operation is clearly apparent after examining what takes place in the aeration cycle. Fresh organic matter adsorbed on the floc is immediately subjected to intense biological action. After one day of aeration, the resulting products are light and voluminous with poor settling qualities. This condition is typified in the vernacular as "poor index" or "bulky".

As the biological process proceeds, some organics are oxidized resulting in production of carbon dioxide; others are converted to more stabilized products. With progressive reduction of volatile matter, settleability seems to improve directly in proportion to the decrease in volatile matter. The detention period of an aeration tank in terms of hours is, therefore, of far less importance than detention period of solids retained under aeration in terms of days.

Once this basic consideration—sludge age—is understood, it can be utilized to control aeration-tank operations by maintaining requisite solids concentration, using sludge re-aeration in other facilities, or adding sewage to returned sludge at selected points in its passage through the aeration tank (step aeration). The latter permits the most flexible application of sludge-age control and a reduction in the size of aeration tanks.

It should not be assumed that there is one magic period of sludge age that is good for all sewage at all times. In sewage purification, a great variety of organic and chemical constituents are being treated. Some of them are more susceptible to biological oxidation than others. Some carbohydrates, for example, are oxidized with relative slowness; their presence may require a greater period of activity than other common materials. The essential requirement is to provide a sludge age that will permit reduction or alteration of volatile constituents so that good settling qualities result.

Most activated-sludge plants are called upon to handle intermittent "shock loads." It is, therefore, important to make the aeration system sufficiently flexible so that sludge age may be adjusted at the first indication of sludge-quality deterioration resulting from altered loading.

Concentration tanks for excess sludge

Sludge accumulated in the aeration system in excess of operating requirements must be wasted. The better the settleability of the sludge through loss of volatiles in the aeration system, the more compact the excess sludge will be and the smaller will be the volume for disposal.

At this stage, it is no longer necessary to maintain the aerobic condition of excess sludge. It may be held in a concentration tank for a period necessary to secure maximum compaction. This period will, of course, be short of that that will allow septic decomposition and gasification.

Seldom is it desirable to waste secondary sludge to primary tanks. The only exceptions might be in cold weather for convenience or with primary tanks having long detention periods. Usually the extra load thrown on the aeration system by an impaired primary effluent more than counterbalances other advantages of this practice. Once material is removed from sewage, it is better not to re-introduce it to the treatment system.

Effect of density currents

The final settling tank is an essential element of the activated-sludge process. Its layout and operating facilities have a bearing on the effectiveness of the process second only to the aeration system.

In the final tanks, large volumes of activated sludge are separated from purified sewage and returned to the aeration system, while clarified liquid is discharged to a waterway. The volume of sludge coming to the final tank will fluctuate with rate of sewage flow. The rate of sludge return must meet this condition and be at least equal that of sludge concentrated in the final tank.

Aerated inflow to final tanks may contain 1,000 to 2,000 ppm. of suspended solids and have a specific gravity greater than that of the clarified liquid in the final tank. As a consequence, the incoming liquid plunges quickly to the bottom of the tank where its gravity is increased by further rapid consolidation. This creates a "density current" of substantial magnitude that flows along the tank bottom, impinges against the far wall, rises vertically and returns along the surface to the inlet.

Effluent weirs at the far end of the tank are in direct line with the density-current upsurge, and some light sludge particles may be carried over the weirs. With a nominal detention period of more than two hours, the density current may arrive at the far end of the tank in 15 min. Better use of tank capacity and a clearer final effluent are obtained when overflow weirs are located near the influent end of the tank to draw the clearer liquid of the returning current.

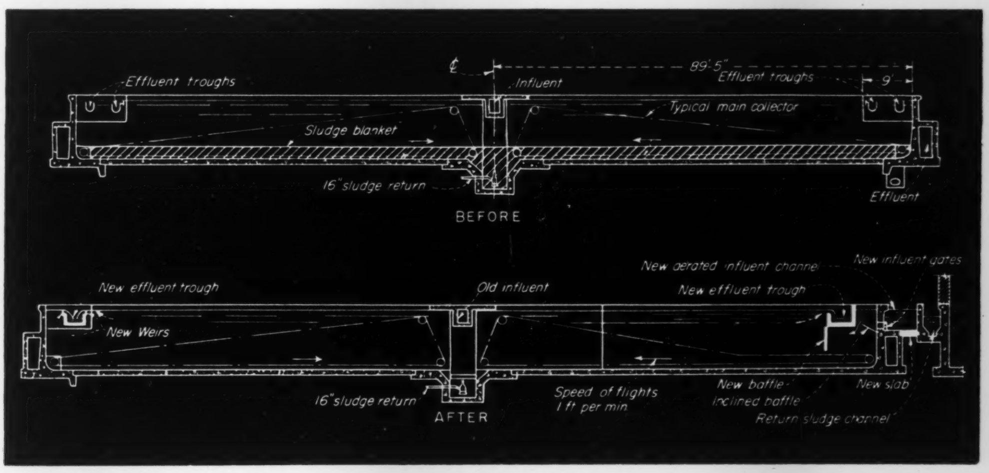
Locating sludge-removal outlet

More important to control of the activated-sludge process as a whole is the location from which concentrated sludge to be returned to the aeration system is removed from the final tank.

Early practice was to remove sludge from the influent end of rectangular tanks. Collector mechanisms with flights moving at one to three feet per minute were provided to move sludge along the tank bottom to the point of removal. Density currents moving at 6 to 10 fpm. in the opposite direction (described above) caused sludge to override the flights.

Since it is not practical to make the flights with sufficient capacity to move the entire volume of returned sludge, this design results in the build-up of sludge blankets—sometimes several feet in depth. This causes long detention of sludge in final tanks with consequent deterioration in quality due to development of anaerobic conditions.

Substantially improved operating results are obtainable by withdrawing sludge at the end of the final tank opposite the inflow. This allows collector mechanisms to assist in moving sludge



RE-LOCATION of points of inlet—to take advantage of density currents in final settling tanks—results in clearer effluent and elimination of sludge blankets at New York's Wards Island sewage treatment plant.

to the more desirable point of removal. Full advantage is thus taken of the density current, the chief function of the collectors being to move particles that settle out of the sludge mass that is moving under its own hydraulic impetus and at a rate faster than the flights.

Wards Island tanks reconstructed

The final settling tanks of New York's Wards Island plant, as shown in the accompanying illustration, have been reconstructed (as far as possible with existing structures) to take advantage of density-current action. Sludge blankets, formerly two to four feet deep, have now almost completely vanished following relocation of the inlets to the tanks. In addition, dye tests indicate that activated sludge remains in final tanks only about 15 minutes. While the plant is laboring under deficient air supply due to clogged plates, alterations of the points of inlet to the final tanks have resulted in greatly improved settling quality of sludge and in more consistent effluents.

Maintaining dissolved oxygen

Maintenance of dissolved oxygen in aeration tanks at all times is another fundamental requirement for successful operation of an activated-sludge plant. The original design for aerating sewage by which compressed air is forced through porous media in the bottom of the tank and tank contents are kept in suspension by spiral flow, has been effective over the years. Better solutions are not now apparent.

But only a small percentage of the compressed air is utilized in satisfying the biological needs of the activated-sludge process. Most of the air-supply energy is expended in maintaining tank contents in uniform suspension with a certain by-product of surface aeration.

In the aeration system, the oxygen demand of the great mass of aging sludge floc is at a relatively low level. As fresh colloidal and dissolved material is adsorbed on the floc, biological activity is stimulated and oxygen demand is immediately increased. This demand can be satisfied either by increasing air supply at the fresh-material inlet or by distributing fresh materials throughout the tank.

Intensity of this oxygen demand apparently can be correlated with abstraction of impurities from the sewage. In other words, when the dissolved oxygen profile through an areation tank breaks upwards, it is an indication that the rapid demand of soluble impurities has largely been satisfied. This criteria can be employed to control amount of air delivered to the aeration system.

Keep air-diffusion media clean

While air-diffusion media made of carborundum of ceramic materials are effective and economical, they are subject to clogging that limits capacity and increases cost of power for air compression.

Bottom clogging due to impurities in the air supply has its obvious solution in better air cleansing either by double mechanical or high-tension electromatic filtration.

Surface clogging of media through intrusion of very fine sand particles, iron salts, organic growths or a combination of salts and growths eludes solution. Periodic removal media for restoration or chemical treatment or surface spalling in place is a routine operating function for economical use of such materials. Perhaps, more satisfactory materials will become available in the future, but, in the meantime, it should be recognized that air-diffusion media must be scheduled for routine re-conditioning.

"Step aeration" for over-design flows

The aeration tanks of the Wards Island plant are also being equipped with conduits that will permit "step aeration" processing. This change is necessitated by the fact that the 180-mgd. plant is being called upon to treat flows up to 240 mgd.

Addition of the new conduits will permit addition of settled sewage to aeration tanks in the first, second or fourth passes as the condition of the sludge dictates. Requisite sludge age will be obtained by maintaining higher sludge concentrations in the upstream end of the tanks. These concentrations will be progressively reduced through the tanks by dilution with settled sewage so that aeration-tank effluent will carry concentrations less than at present. This means that a relatively smaller amount of sludge solids will be circulated through the final tanks and a greater percentage of sludge will be in the aeration tanks under aerobic conditions at all times.

With an adequate air supply, the capacity limitation of this plant rests in the hydraulic and area restrictions of the final tanks.

"Modified sewage aeration"

A modification of the conventional activated-sludge process has been recently developed for use where only intermediate treatment is required. This process has been designated in New York, where it was originated, as "modified sewage aeration." Some engineers prefer to call it "high-rate activated sludge". While the mechanics of operation of this process are quite similar to those of the conventional process, essentials differences are involved.

In the "modified" process, sludge is not allowed to exceed an age of from 8 to 12 hours. During this short life, it acquires zoogleal bacteria necessary for purification but the sludge is not altered to the extent that it loses the settling qualities of a primary sludge. It might be said that this method uses activated sludge in its incipient development.

In practical operation, the modified method means that, to minimize sludge age, low concentrations (varying with the detention period and strength of sewage) are carried in the aeration tank. As the essential activated-sludge action is dependent on surface area and time of contact, the resulting purification is somewhat less than that obtained by the complete conventional cycle.

At the Jamaica, N. Y., plant, which functions on the "modified sewage aeration" basis, removal of more than 75 percent BOD and 80-85 percent suspended solids, are common. These results are secured by preliminary treatment with coarse screens and grit chambers, 2.0-2.5-hr. aeration and 2.5-3.0-hr. final sedimentation.

Excess sludge pumped to digestors has a solid content of 5-7 percent. Air requirements are but slightly over one half of that for the full-cycle activated sludge plant.

While hourly variations in effluent quality are considerable, average performance is consistent.

The modified method of operating activated-sludge plants would seem to be adaptable to many places where intermediate treatment will be acceptable. It offers advantages in lower capital cost and economies in operation and in sludge disposal.

The activated-sludge process has proved over the years to be an effective method of sewage treatment. Its possibilities and limitations have been clearly recognized. Further improvements in the process seem to lie in full appreciation and use of possibilities inherent in the process.

When an activated-sludge plant is designed, it is essential to proportion structures and appurtenant facilities to the requirement of the particular sewage to be treated and to meet the required end performance. Substantial cost savings plus better and more stable operating results are possible if full advantage is taken of available knowledge of the process.

AN ARTICLE TO MOLD THE FUTURE

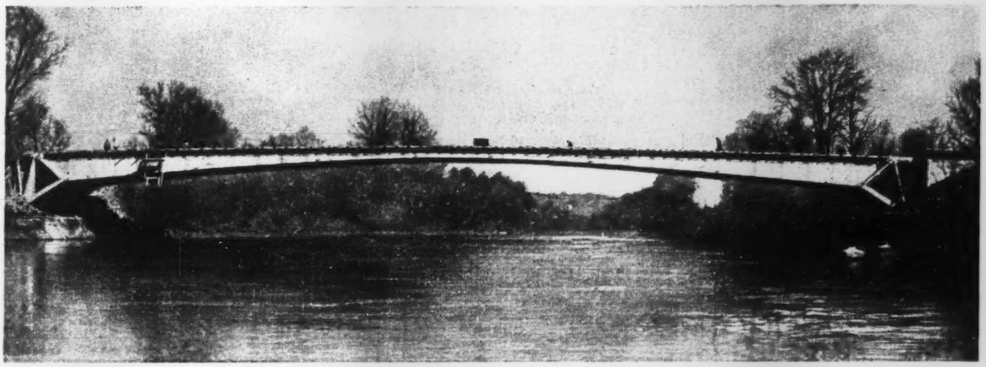


FIG. 1. PRECAST CONCRETE UNITS were assembled over the Marne at Esbly, France, and prestressed to form a flat-arch bridge spanning 243 ft. with a crown depth of only 37 in. (H. Baranger Photo)

Prestressed Concrete—A New Frontier

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APPLICATION of a virtually unexplored concept–prestressing–to concrete construction makes possible remarkable advances in structural engineering:

Eugene Freyssinet's five flat-arch bridges over the Marne near Meaux, for instance, which have a depth at the crown of only 37 in. for a span of 243 ft. (Fig. 1 shows one of these.).

Roebling's 14,000-sq.ft. jointless slab in a Chicago warehouse, which is only 3 in. thick yet does not show even a hair crack, though it has been subjected to heavy loads and large temperature variations for 2½ years.

Gustave Magnel's hangars at Brussels airport with 165-ft. beams, and Preload Corp.'s dome at Kansas City spanning 180 ft., though only 5 in. thick.

The secret lies in applying forces to the concrete to overcome the tensile stresses caused by loads, volume changes and impact. This creates a concrete capable of taking tension without cracking, makes it an efficient building material with many applications apart from the spectacular ones cited.

The great shortcoming of concrete is that its strength in tension is much smaller than in compression, so that it cracks when subjected to low tensile stresses. To overcome this weakness, the usual procedure has been to reinforce the concrete—put in steel rods to take the tension. The technique has proved very successful with respect to safety, but it has not prevented concrete from cracking.

Full use made of strong materials

In recent years, however, great strides have been made in improving the quality and strength of both concrete and steel. Reliable concrete with a compressive strength of 9,000 to 12,000 psi. and suitable steel with a tensile strength of over 200,000 psi can be attained readily.

However, these materials cannot be used to full advantage in reinforced concrete beams or slabs. In the first place, the added expense of obtaining high-strength concrete is not warranted. Only one-third the concrete in a rectangular beam—the part in compression—carries stress; the part in tension is assumed to be cracked and not contributing to the resisting moment. Secondly, if high-strength steel is used, the strain will be several times that of mild steel, and wide cracks will be formed in the beam under working loads.

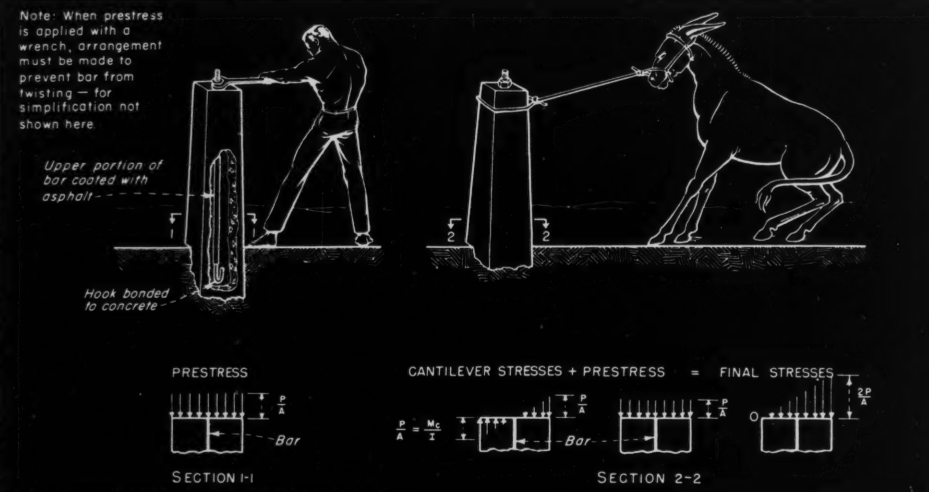
But full use can be made of the best concrete and highest strength steel obtainable if the concrete is prestressed.

Since the steel is stretched independently to compress the concrete, steel with high tensile strength is an asset. The reasons for this are that a large prestress can be applied with a small amount of steel and the stress losses in the steel, due to plastic flow and shrinkage of the concrete, become proportionately smaller as the applied tension is increased. High-strength concrete is advantageous because the amount of prestress that can be applied increases with the compressive strength of the concrete. And obviously the greater the prestress the greater is the bending moment that a prestressed concrete beam can carry.

Concrete becomes elastic

Prestressing converts concrete into an elastic material—one for which the stresses and deformations can be accurately computed. Since the entire concrete section carries bending moment, a prestressed beam can carry much heavier loads without cracking than a reinforced concrete beam of the same section. Or it can span much greater distances than has so far been possible with conventionally-designed beams. In fact, prestressing places con-

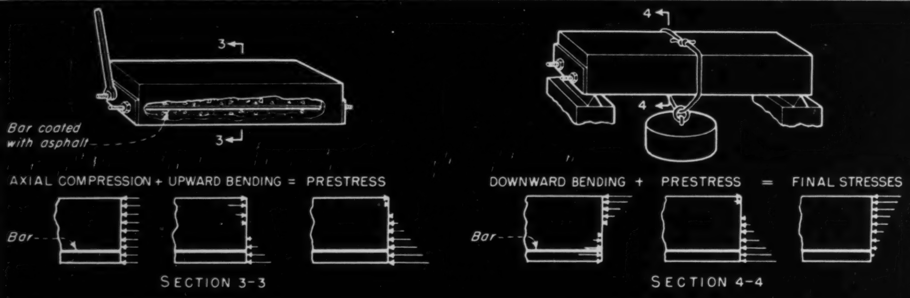
Some Principles of Prestressing:



Note: When prestress is applied with a wrench, arrangement must be made to prevent bar from twisting — for simplification not shown here.

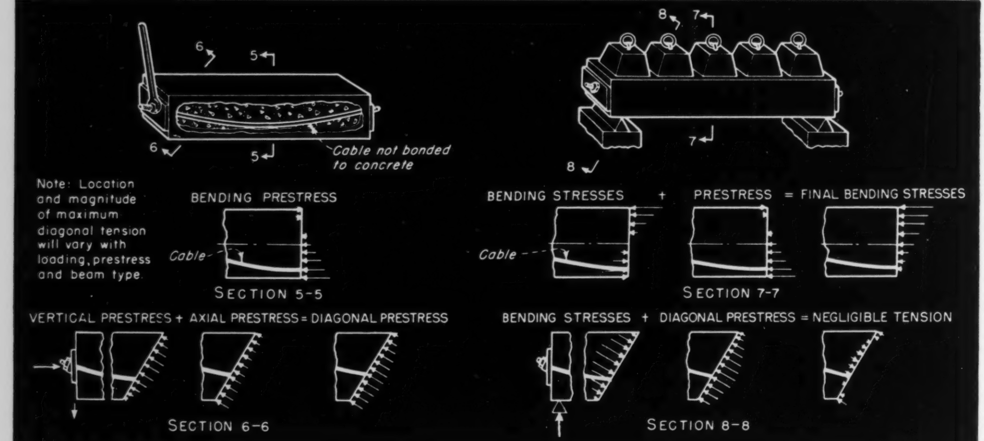
Upper portion of bar coated with asphalt
Hook bonded to concrete
1
1
2
2
PRESTRESS
$\frac{P}{A}$
Bar
SECTION 1-1
CANTILEVER STRESSES + PRESTRESS = FINAL STRESSES
$\frac{P}{A} = \frac{Mc}{I}$
$\frac{P}{A}$
Bar
$\frac{P}{A}$
0
$\frac{2P}{A}$
SECTION 2-2

FIG. 2 POST CENTRALLY PRESTRESSED by tightening nut on top will not sustain tension until prestress is overcome.



3
3
Bar coated with asphalt
4
4
AXIAL COMPRESSION + UPWARD BENDING = PRESTRESS
Bar
SECTION 3-3
DOWNWARD BENDING + PRESTRESS = FINAL STRESSES
Bar
SECTION 4-4

FIG. 3 BEAM PRESTRESSED by tightening nuts on straight bars near beam bottom cannot crack under loads until prestress is counteracted. Stresses are much lower than for centrally applied prestress.



Note: Location and magnitude of maximum diagonal tension will vary with loading, prestress and beam type.

6
5
6
5
Cable not bonded to concrete
8
7
7
8
BENDING PRESTRESS
Cable
SECTION 5-5
BENDING STRESSES + PRESTRESS = FINAL BENDING STRESSES
Cable
SECTION 7-7
VERTICAL PRESTRESS + AXIAL PRESTRESS = DIAGONAL PRESTRESS
SECTION 6-6
BENDING STRESSES + DIAGONAL PRESTRESS = NEGLIGIBLE TENSION
SECTION 8-8

FIG. 4 UNIFORMLY LOADED BEAM prestressed with cable curved to form a parabola is more efficient than the beams in Fig. 1 and 2. There is no tension due to bending, and diagonal tension is practically negligible.

crete in full economic competition with structural steel.

One of the most impressive characteristics of prestressing is that it enables long-span beams to be constructed of short, precast units. Much like a group of books can be lifted from a shelf by applying longitudinal pressure to the end pair, such a beam is given a monolithic character by the prestress.

Another big advantage is that if heavy loads induce large deflections and cause slight cracks, a prestressed beam will recover its original shape and the cracks will be effectively sealed when the loads are removed. Tests were made by the John A. Roebling's Sons Co. in which a 10-ft. long, 1⅝ in. thick, prestressed concrete slab was deflected as much as 3 in., or 1/40th the span. Despite this large deflection, the slab returned to its original shape on removal of the load, no cracks being apparent.

Erection of prestressed, precast concrete structural members, even of very long spans, does not differ very much from that of structural steel. A few extra prestressing cables can easily be put in to take care of temporary stresses (such as those due to cantilever erection) and later removed. These members can withstand rough handling because of their resilience.

Principles of prestressing

Prestressed concrete is not entirely new. It dates back at least to 1886, when a patent specification was issued to P. H. Jackson of San Francisco. In 1928, R. E. Dill of Alexandria, Neb., obtained a patent for the construction of prestressed concrete units with unbonded steel. In that year also, Eugene Freyssinet filed his fundamental patent in France; he demonstrated that high-strength steel is essential to the success of prestressing.

Since then, many prestressed concrete structures have been erected throughout Europe, the contracts being obtained in sharp competition with other methods of construction, because prestressing was shown to be more economical. In the United States, prestressing has been used for water tanks, pressure pipes, piles, a warehouse floor slab, a suspension bridge roadway slab and a bridge now being built in Philadelphia. In South America, several large prestressed bridges are planned or under construction.

The basic principles of prestressing were illustrated simply in Dill's patent specifications. He showed how a post can be centrally prestressed by a bar threaded at one end and hooked into the concrete at the other (Fig. 2). With the exception of the hook, the bar was coated with asphalt, prior to embedment in the concrete, to prevent bond. After the concrete hardened, the rod was stressed by tightening a nut on the threaded end. This placed a uniform compression on the concrete. Then, if the post were subjected to cantilever bending moment, the stresses on any cross section were the sum of the precompression and the bending stresses. There could be no tension anywhere in the post until the precompression was overcome.

Beam stresses canceled out

For a simply-supported beam, Dill omitted the hook and used instead asphalt-coated bars with two threaded ends, to enable them to be tensioned from either end. Placed near the bottom of the beam, the bars—when stretched by tightening of the nuts on the threaded ends—caused a relatively large compressive stress at the bottom of the beam and a small tensile stress at the top (Fig. 3). Since loads produced tension on the bottom and compression on top, the prestresses and load stresses were of opposite sign and tended to cancel each other. Again, there could be no tension in the concrete at the critical section until the axial and bending precompression stresses in the concrete were overcome.

The distance between the steel and the neutral axis of the beam in Fig. 3 was a constant. However, varying this distance in accordance with the bending moments caused by the applied load is much more effective. For a uniform load, more economical results are obtained with the steel forming a parabola with the vertex at the center of the span near the bottom of the beam (Fig. 4). Then, the bending-moment diagram for the prestress has the same shape as the moment diagram for the uniform load, but the ordinates differ in sign. The final stress at any section is the sum of the stresses due to these moments, plus the axial precompression.

Because the slope constantly changes, the steel exerts an uplift on the beam throughout its length. These forces reduce the shear and consequently the diagonal tension. This is further reduced by the axial precompression stress, which is opposite in direction to the horizontal shear.

Another method of varying the distance between the neutral axis and the steel is to keep the steel straight and camber the beam or vary its moment or inertia. In this manner A. Paduart built a pedestrian overpass of 145-ft. span in Belgium, and experimental 100-ft. beams with rises of 1/60th to 1/90th of the span. Magnel also favors this procedure because it eliminates the need for friction-reducing devices at points where the steel changes direction. His continuous bridge under construction at Sclayn near Namur, with two 205-ft. spans, contains only straight prestressing steel, the concrete soffits being arched to provide the required design eccentricities.

If, after the prestress is applied, the concrete shortens because of plastic flow or shrinkage, the tension in the steel and the prestress in the concrete are reduced. As Freyssinet showed, the losses in tension can be very large for normal low-carbon steel rods, which cannot be stretched safely to more than 30,000 psi. For instance, if the shortening amounts to 0.0005 in. and the modulus of elasticity of the steel is 30,000,000, the loss of stress will be 15,000 psi., or half the stress available for tensioning. Obviously, normal steel has little reserve for volume changes in the concrete.

Type of steel and concrete desired

High-strength wire must be used. With initial stresses of 150,000 psi., this steel can take the losses of 20,000 to 30,000 psi. that usually occur without appreciably altering the character of the structure.

The steel should preferably be cold-drawn wire with a tensile strength of over 200,000 psi. and a proportional limit larger than the design stress. Within design ranges, it should not creep.

For economy, the volume of concrete must be kept to a minimum, not only to reduce dead weight, but also to minimize the amount of steel needed for prestressing. Hence the concrete should have a compressive ultimate strength of at least 5,000 psi. to justify a 2,000-psi. design stress, and should be cast in an efficient shape, such as an H or hollow rectangle.

The question of bond

The prestress can be applied to the concrete by the wires with or without bond. With bond, the steel is tensioned against exterior anchors, then embedded in the concrete, and after the concrete has hardened, the steel is released from the anchors. In this manner, precompression is applied to the beam along its entire length, but the exact distribution of stress is in doubt.

When the steel is not bonded to the concrete, it is generally placed in ducts or pipes in the concrete and tensioned against the hardened beam. With this method the stress distribution is known at all times, and the need for heavy independent anchors is eliminated.

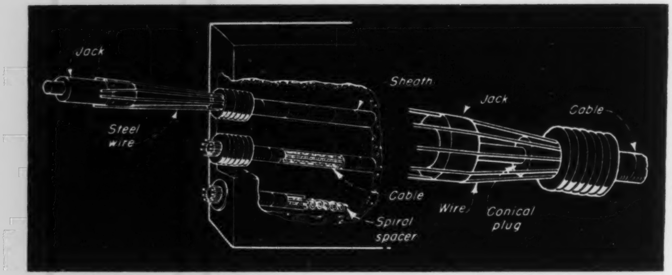


FIG. 5. THE DOUBLE-ACTING JACK used by Freyssinet stretches the wires with one action (left) and pushes plug into place to anchor them with second action (right).

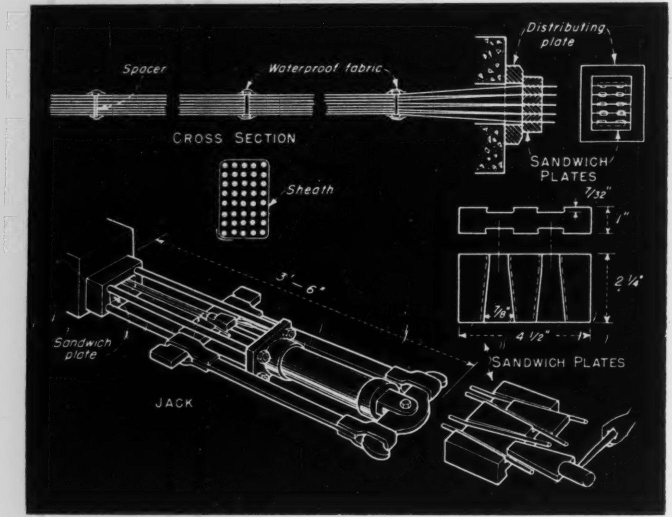


FIG. 6. MAGNEL'S JACK stresses two wires at a time. These wires are then anchored by forcing steel wedges into wedge-shaped grooves in a cast steel "sandwich" plate.

Bonded prestress was initiated by Freyssinet and perfected by Ewald Hoyer in Germany. It is an excellent method for short units, which require small prestress forces, although the losses from volume changes are considerable. Strong anchors must be used to take the thrust of the wires before it is released to the concrete.

Generally, the maximum size wire used for bonded prestress is No. 6 bridge wire of 0.192-in. dia., but even this small size is questionable. The drawing of the wire leaves it with such a smooth surface that additional provision for gripping the concrete is desirable.

Hoyer has placed bonded prestressed concrete on an industrial basis for short spans. He uses piano wire of less than ⅛-in. dia., with a tensile strength of 350,000 psi. and a proportional limit of about 85 percent of this. (Because of the smoothness, notwithstanding the small size of this wire, the amount of bond obtained is open to question.) The anchorages are placed several hundred feet apart, and the forms for several members are placed between them.

Hoyer threads the wires through the forms, applies the tension by jacking against the anchors, places the concrete, and then, after the concrete has hardened, cuts the wires. With several rows of forms, prestressed beams are produced in large quantities.

In the U. S., Schorer has developed an effective method for bonded prestress without outside anchorages.

Both Freyssinet and Magnel precast the concrete with the cables in ducts, tension the steel with jacks acting against the concrete, and then grout the cables in, establishing bond. On the other hand, using a similar procedure, the Roebling Company omits the grouting, to assure independent action of the cables. Galvanized stranded cables, which are immune to corrosion from humidity, are used. Surrounded by concrete, they are protected against harmful chemical atmospheres.

For slabs or beams in which the cables have a small curvature, Roebling passes the steel through pipes or paraffined paper tubes to prevent bond. For long spans, a hollow rectangular beam is used with cables extending its length in the hollow in the form of a parabola and anchored over the supports (Fig. 8). At frequent intervals, the steel bears against saddles, which are attached to internal concrete diaphragms between the webs and which permit sharp curvatures in the cables without fear of undue friction losses. Tensioning the steel causes upward forces at the saddles, producing moments and shears opposite in sign to those caused by loads. Also, the concrete is kept in compression by the axial thrust exerted by the anchor plates at the ends.

A similar technique was used by Franz Dischinger in his 223-ft. cantilever bridge erected in 1939 at Aue, Germany. He used exposed high yield-point rods, anchored at the ends and jacked down at intermediate points against concrete diaphragms.

Dead-load moments and shears can be eliminated entirely, if desired. A part of the live load is carried directly by the cables. In design, this load is distributed between the cables and the concrete in the same manner as it is apportioned between cables and stiffening trusses for suspension bridges.

Until recently, the maximum size used for single wires with end anchorage and no bond has been a No. 6 bridge wire, but now a 0.276-in. dia, wire has become available. In contrast, any size stranded bridge cable may be used, limited only by the capacity of the prestressing jack. A maximum size of 2½ in. is suggested by the Roebling Company for bridge rope with an allowable tensile stress of 100,000 psi., for use in simply supported bridges having spans up to 250 ft.

Tensioning and anchoring techniques

Various methods are in common use for tensioning the wires and anchoring them. Freyssinet, for instance, uses double-acting jacks. He anchors the wires between a conical wedge and a conical funnel cast in the end of

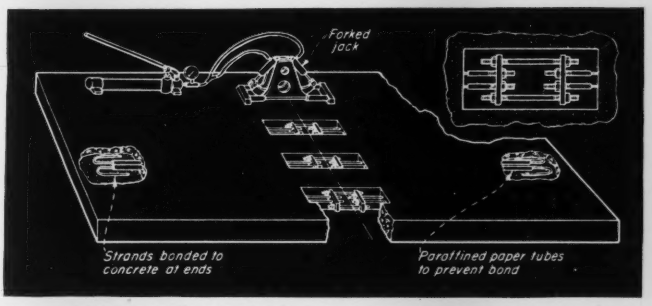

Forked jack
Strands bonded to concrete at ends
Paraffined paper tubes to prevent bond

FIG. 7. **PRESTRESSING METHOD of the Roebling Co. in which wire strands are anchored at the ends of a slab and tensioned by forked jacks at the center.**

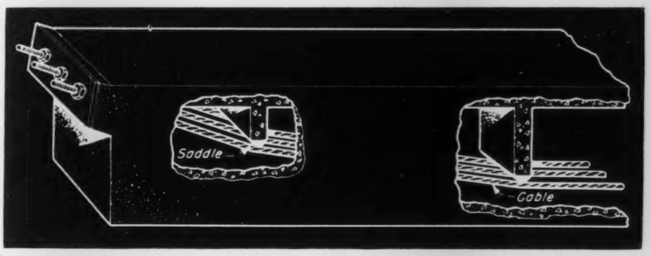


FIG. 8. **HOLLOW BEAM prestressed with a cable following a parabolic curve.**

each cable duct (Fig. 5). To apply the prestress, he fixes the wires two at a time by wedges to the jack, and after all the wires are connected, he applies the tension. He generally stresses 12 to 20 No. 6 wires at the same time, applying a force of 40 to 70 kips (design stress, after allowing for losses, 120,000 psi.). When the wires are properly tensioned, the conical wedge is pushed into the funnel by a second action of the jack, clamping the wires against the metal spiral lining of the funnel. Finally, he grouts the wires in place through an opening in the wedge.

Magnel advocates tensioning only two wires at a time, contends that stressing a greater number does not result in equal tensioning of all wires. He uses a jack with a capacity of less than 10 tons. The wires, tensioned two by two, are anchored in the same sequence to a cast steel "sandwich" plate, which acts against a cast steel distributing plate (Fig. 6). Each sandwich plate is provided with four wedge-shaped grooves, in each of which two wires are secured with a cast steel wedge. He also grouts the wires in place, to protect them against corrosion and to supplement the anchorage.

The principal advantage of this method is that cables containing a large number of wires can be used. However, it is somewhat more expensive than Freyssinet's method, and tensioning takes longer.

The method of anchoring accounts for the different arrangement of wires in the Freyssinet and Magnel systems. Using a conical anchorage, Freyssinet groups the wires of each cable in a circle, preferable in holes cast in the concrete, keeping them in position with spiral wire spacers (Fig. 5), or else he wraps the cable with bituminous paper or thin steel sheeting before placing the concrete. On the other hand, Magnel, because of the arrangement of the sandwich-plate anchorages, sets his wires in a rectangular pattern, using perforated sheet-metal spacers. They are placed inside a rectangular metal duct, which can be removed after the concrete has hardened and before the wires are prestressed.

As an alternative procedure, the Roebling Company has developed a method of prestressing in which the ends of wire strands are anchored at the ends of the beam or slab by bond and tensioned by forked jacks at the center (Fig. 7). The jacks pull together opposing pairs of strands, which then are connected by plate and bolt assemblies.

However, the advantages of the Roebling technique, whether end or center prestressing is used, is that it contains nothing even remotely experimental. The strands are provided with sockets or swaged terminals to enable them to be attached to the jacks, anchor plates or each other with screw fittings commonly used in the cable industry. The stranded cables are made immune to creep in manufacture, as shown by the record of numerous suspension bridges where this type of cable has been used at 100,000 psi. Not bonded to the concrete, except where desired for anchorage, the cables may be adjusted at any time to compensate for volume changes of the concrete, or to enable the beam to take greater loads than originally planned. Also, when desired, the cable stresses can be checked.

Method for tanks and domes

The Preload Corp. applies prestress to walls and domes of circular tanks by wrapping an endless wire under tension around the structure. The wire is drawn through a die to develop the required stress. Initially of 0.162-in. dia., with a yield point exceeding 180,000 psi. and an ultimate strength over 220,000 psi., the wire is stressed to 140,000 psi. as it is laid around the concrete, allowing 30,000-psi. stress loss from all causes.

Generally, winding starts at the bottom of the tank or dome ring, with the wire secured to anchor bolts, and each coil is connected to the following coil with a special torpedo splice. At the top, the wire is again fastened to anchor bolts. Finally, a concrete covering is placed over the wires—generally pneumatically.

Prospects for prestressing in U. S.

Prestressed concrete will surely be used extensively by American engineers once they are familiar with its merits. The design is simple and based on conventional procedures as practiced with other homogeneous materials. Nevertheless, structural solutions far beyond our present standards of concrete engineering can be worked out with comparative ease. In everyday work, prestressing should relieve many structural worries derived from the weakness of concrete in tension and the subsequent cracking.

In its application, prestressed concrete offers strong possibilities for mass production of structural members under close shop control. Used in conjunction with industrialized precasting, and easily erected, it should be fully competitive with other structural materials in the U. S. as it is in Europe.

AN ARTICLE TO MOLD THE FUTURE

Pile Foundations—Less Guess, More Design

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MORE MONEY could be saved, more certainty and safety introduced into foundation practice, by accurately determining pile lengths than through any other development. If the millions of piles that will be used in the next fifty years could each be driven to exactly the correct depth to preclude or predetermine later settlement, there would be no cracked structures to repair. If the amount of piling needed for a job could be more accurately estimated, the costly practice of making up for overlengths or underlengths would be eliminated.

From an economic point of view, pile length determination can be said to be the most fruitful current problem that foundation engineers can undertake to solve.

Fortunately, the accumulating knowledge of the science of soil mechanics offers a key to the solution. For end-bearing piles on relatively unyielding strata, required pile lengths, of course, are readily found: just make enough borings to locate the bearing strata. It is with piles that depend wholly or partially on skin friction that troubles abound. If they are to be overcome, such time-honored practices as the use of arbitrarily selected "safe-loads" and of pile-driving formulas must be altered and in some cases abandoned.

The necessary new concept would be to design the piling for the settlement that the supported structure can withstand. Less guess, more design is the necessary requirement.

Historically, the design of pile foundations has been predicated upon the more or less arbitrary selection of an allowable or safe load per pile. The load to be supported divided by the allowable load per pile gave the requisite number of piling. Then, the length of pile was determined by some local rule of thumb or formula, usually based upon the difficulty of driving the piles.

This apparently simple procedure involves a multiplicity of unstated and frequently unrecognized assumptions which may be of paramount importance in the satisfactory behavior of the structure. Foremost among these unstated assumptions is that the deflection or settlement of the piling will be within the limits permissible and acceptable for the structure concerned. Since the selection of the "allowable load" has frequently been predicated upon experience or observations of other structures in the vicinity, the assumption includes a stipulation that settlement which has been acceptable for previous structures within the range of experience will also be appropriate for the structure being planned. By the same token it is assumed that the loads on the proposed pile groups will cause settlements similar to those previously experienced. The possible fallacy of such broad assumptions may be appreciated by considering the settlements and deflections that might be permissible for certain extremely different types of structures—such as a light, steel-frame industrial building on the one hand, and a heavy, relatively brittle masonry building on the other.

Disadvantages of formulas

As the theories and concepts of other phases of structural design and analysis progressed through the years, engineers of nearly a century ago came to realize that a more rational approach to the problem of determining pile lengths was also required. Consequently, the engineers of the day determined to investigate the theory that the load-bearing capacity of a pile was proportional to the striking energy delivered to it in driving the last few inches, and on this basis to develop a formula to be used as a criterion in controlling pile driving. A large number of formulas was presented to the engineering profession as a result. The years have produced others.

Pile driving formulas are, of course, one means of determining pile lengths; however, there is no assurance that the lengths so determined are correct, or economical. In checking pile driving formulas by means of pile loading tests, it has been found by the author and his associates, as well as by many others, that the actual supporting capacities of the driven piling are often greatly at variance with the capacities computed by the different formulas—which in turn vary greatly from each other.

Shortcomings of test piles

With the realization of these conditions many engineers have felt that some other criteria must be developed to secure economical and adequate pile foundations. One approach to the problem may be made by driving a few representative piles to arbitrarily chosen depths and subjecting them to static loading tests to determine an "allowable load per pile." This procedure is the basis of some building code requirements for pile foundations. However, upon completion of the pile loading tests the proper interpretation of the results usually presents a problem. Questions arise such as:

(a) What point on the test curve of the pile under load actually represents a real yielding or beginning of failure?

(b) What factor of safety should be used in relation to the yield point of the pile tested?

(c) What is the ratio between the supporting capacity of a pile under the temporary test load and the permanent load imposed by the completed structure?

(d) What is the relation between the settlement of one pile and a pile group of the size to be used in the proposed structure?

(e) What is an allowable settlement for the proposed structure?

These questions have been answered differently in different localities and it is logical that they should be, since local conditions and behavior may warrant different specific conclusions, but not necessarily generalizations. Conditions for which a satisfactory solution simply will not be reached by use of any conventional driving formula or load test procedures are found in many areas of filled ground. For example, if a fairly thick layer of very soft or compressible soil underlies a fill through which it is necessary to drive piling there may be subsequent consolidation of the soft soils which will permit subsidence of the ground surface producing a downdrag force transmitted to the piling. Thus a portion of the frictional resistance experienced in driving may actually tend to cause the pile to settle severely rather than acting to support it. There is no means of evaluating this downward force by a pile driving formula or a pile loading test because the force does not exist when the pile is being driven. In fact it may not be noticeable for months or even years after the construction is completed.

Concept of permissible strains

With the development, during approximately the past 20 to 25 years, of techniques and methods for evaluating the deflections of soils under various loading conditions it is becoming possible to shift the emphasis in the design of pile foundations from the arbitrary determination of a "safe allowable load" to a more rational evaluation of the deflections that may be considered satisfactory for the particular structure. The concept stated by J. A. Van den Broek, ("Theory of Limit Design" *Transactions*, Am. So. C. E., Vol. 105, 1940, Page 638), "that the emphasis be shifted from the concept of strength" to that of "permissible deformation" is fully as applicable to pile foundation design as it is to design of the superstructure.

In the problem of foundation behavior, to an even greater extent than in that of structural behavior, it is important that the analyses indicate the actual deflections of the various portions of the structure. A relatively great factor of safety in the foundation for a portion of the structure as contrasted with another portion may actually result in a lowering of the overall strength and performance capabilities of the structure by introducing distortions and strains that are actually detrimental.

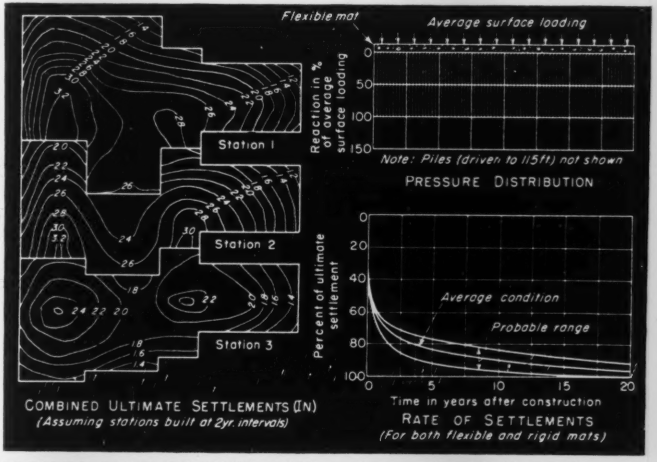
Pile lengths, therefore, can best be determined by consideration of the soil properties underlying a particular site, rather than by relying entirely on pile loading tests or on one of the pile driving formulas.

In this connection, several investigators have developed methods of pile capacity analysis that offer very encouraging promise of satisfactory use and practice under a wide variety of field conditions.[1] The analysis and selection of pile lengths has now reached the stage whereby all of the methods may be advantageously combined to provide a satisfactory and practical guide for construction under a wide variety of conditions:

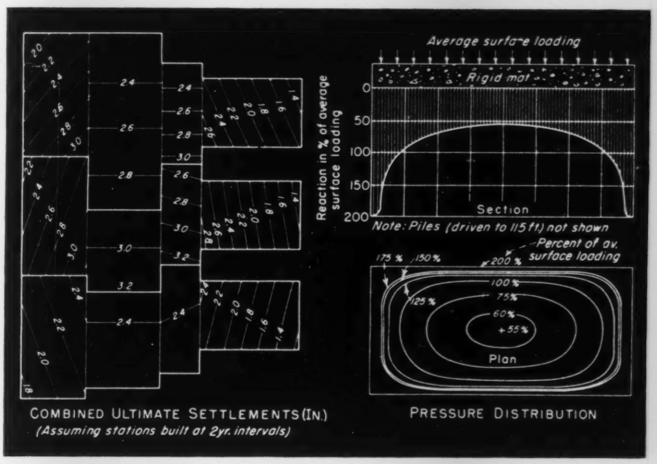
(a) The soil conditions underlying a site may be investigated by means of test borings, and undisturbed soil samples extracted to determine the soil properties.

(b) Utilizing the data thus obtained, analysis may be performed to

Choice of foundation to be used is based on settlement patterns of . . .



FLEXIBLE MATS ON PILING which produce a uniformly distributed pressure under electric generating station loads, and . . .



RIGID MATS ON PILING which create high pressure areas near the edges, a condition which may or may not be a disadvantage depending upon the type, size and location of loads to be supported.

predetermine the pile tip elevations required to support a certain load within permissible settlement limits.

(c) Test piling of one or more suitable types may then be driven to the depths indicated in the analyses and loaded to determine their yield point capacities and behavior under static or oscillating and repeated loads as a check on the suitability of the computed pile capacities. Such studies often enable advantageous comparison of the costs of several feasible types of piling and loadings.

(d) When the piling is actually driven for the structural foundation, it is usually helpful to drive the first piles near one or more of the test borings for which the soil conditions were analyzed, and then establish maximum and minimum driving criteria for routine control of the construction. If unexpected subsurface conditions are encountered during construction, they may be investigated and appropriate measures taken to assure adequate piling being installed.

Settlement patterns

The use of various analytical methods of evaluating static supporting capacities based upon tests of the soil properties, field loading tests, and dynamic driving behavior is a significant step in selecting loadings and lengths and controlling the installation of suitable pile types. However, it is the stability and settlement pattern of the entire pile installation, as a group or multiplicity of groups, that will determine the satisfactory or unsatisfactory behavior of the completed structure.

Even though the present state of knowledge concerning the patterns of stress distribution in foundation materials is limited and subject to numerous indeterminate factors, it is even now possible to evaluate within practicably helpful limits of accuracy the behavior of pile installations. The writer has been associated with the design of several projects in which the future settlements of pile-supported structures have been analytically determined prior to construction, and have been subsequently checked by measurements in the field after construction has been completed. In the cases checked there has been sufficiently close agreement between the computed and the measured settlements to justify the decisions reached regarding the foundation details needed to realize satisfactory performance of the structures.

The advent of the electrical resistance-type strain gage has enabled use of a method of determining the stress distribution in a pile. The gages can be placed within the pile at the time of casting or attached to a pile at different locations throughout the pile length.[2] The piling may be driven to a predetermined tip elevation and then subjected to static or dynamic loading tests. The strain gages measure the strain at different elevations in the pile, and permit an evaluation of the proportion of the applied load that has been transmitted to the soil above the location of each strain gage.

The analyses of relative settlements and consideration of the corresponding internal strains within the superstructure require some additional amount of study in field, laboratory, and office. However, it is believed that such methods are in keeping with advanced and more refined analyses of the superstructure, and become essential if it is to be assured that the behavior of the superstructure will be reasonably close to that which is intended and provided for in the design.

An example of this type of analysis is shown by the accompanying illustration depicting the estimated settlements of pile-supported electrical generating equipment for a large power plant in the state of Utah, designed by the power division of the Bechtel Corp., if, on the one hand, the loads were transmitted to the piling by means of a group of uniformly loaded but flexible mat foundations, or, on the other, if a group of rectangular rigid foundation mats were utilized. It can be seen that the pressure distribution beneath a rigid mat is considerably greater near the edge than in the center, whereas, in the case of a flexible mat the pressure would be uniformly distributed over the entire area of the foundation.

The use of analyses such as these can be of great assistance in considering the limiting strains to which a given structure may be exposed, and thus enable the designer to provide suitable reinforcing distributed in a manner that will be effective in preventing any serious damage.

Although for some complex structures the analyses will not be precise, they can indicate maximum conditions of possible stress and strain and probable limits of the stress variations in various parts of the structure. For the example illustrated, the mat could have been reinforced to prevent damage if the supporting reactions were distributed as though the mat were absolutely rigid. Then such slight distortions as would be permitted within the limits of stiffness of the mat and superstructure would reduce some of the stresses which the mat would be required to resist.

In this project the structural engineers were able to make an approximate evaluation of the rigidity of the mat as compared to the expected pattern of subsidence of the supporting soils. By so doing the pile spacing was varied to place the greatest number of piles in areas where the principal reactions are expected, rather than employing a more conventional pile spacing based upon assumed uniformly-distributed support. This design maintains a relatively uniform and consistent factor of safety throughout the structure, and also permits a considerable cost saving in the reinforcing of the mat.

Suiting pile length to structure

Similar types of analyses were made to evaluate the probable settlements of some of the lighter structures, such as cooling towers and stacks, assuming that the structures might be supported upon several different lengths of piling. As a result of these studies it was concluded that 30 to 50 percent shorter piles should be used for certain of the lighter structural units. This selection of piles lengths, suited to the characteristics of each particular structural unit, results in a considerable saving in pile costs while actually minimizing the probable differential settlements between the heavier and lighter structures comprising this extensive electric generating plant.

Analyses of similar nature have been made to evaluate the strains which may be imposed upon other types of framed structures supported by separate groups of piling, and in some cases, the lengths of piling selected have been principally governed by desired limitations of settlement rather than by any consideration of a "factor of safety" in relation to the failure load on an individual pile.

Although at present this type of analyses is in a somewhat formative stage, it is believed that such an approach to the problem of pile length determination will often be of material aid in securing more suitable and economical foundations.

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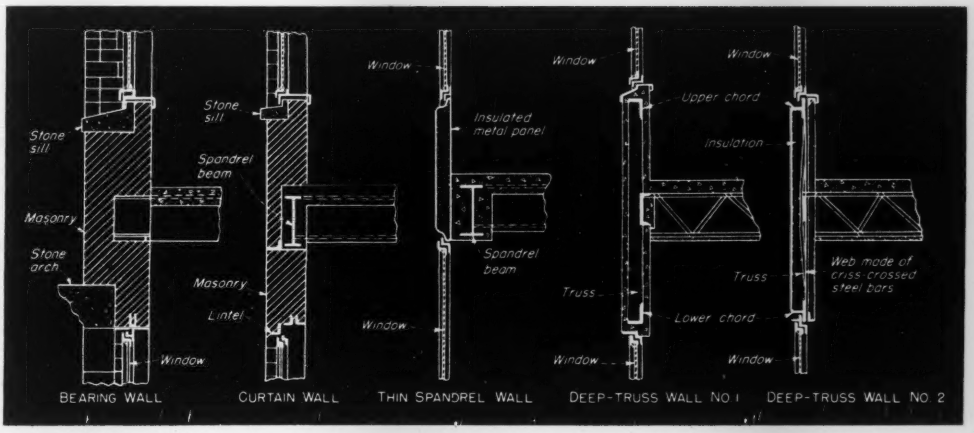
[1] "Experiences with Predetermining Pile Lengths, by William W. Moore, *Proceedings* Am. Soc. C.E. Nov. 1947 pp 1341 to 1358.

Discussion of "Experiences with Predetermining Pile Lengths", by George F Sowers, *Proceedings* Am. Soc. C.E., June 1948, pp. 962 to 967.

"Some Recent Tests on the Bearing Capacity of Piles" by A. Mayer, Technical Institute of Construction and Public Works, 12 Rue Brancion, Paris, Pamphlet No. 34, Series 1, March 31, 1947.

[2] "Electrical Resistance Strain Gages for Determining the Transfer of Load from Driven Piling to Soil," by L. Leroy Crandall, *Proceedings*, Second International Conference of Soil Mechanics and Foundation Engineering, Rotterdam, Holland.

AN ARTICLE TO MOLD THE FUTURE


Stone sill
Masonry
Stone arch
Window
Stone sill
Spandrel beam
Masonry
Lintel
Window
Insulated metal panel
Spandrel beam
Window
Window
Upper chord
Truss
Lower chord
Window
Window
Insulation
Truss
Web made of criss-crossed steel bars
Window
BEARING WALL
CURTAIN WALL
THIN SPANDREL WALL
DEEP-TRUSS WALL NO. I
DEEP-TRUSS WALL NO. 2

ALL EXTERIOR WALLS once were load-bearing (left), but skeleton-frame construction made it possible to develop . . .

Lighter, Thinner Walls for Buildings

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Many city codes require the curtain walls of multistory office and apartment buildings to be of masonry at least 8 in. thick. If, instead, they permitted lighter weight, thinner walls, construction costs would drop and rental incomes increase.

Walls can be designed to satisfy accepted performance standards and yet weigh only 5 to 10 percent as much as conventional masonry walls. As a result, handling costs can be lowered and considerable economies effected in structural frames and foundations.

Decreasing the thickness of a wall increases the rentable floor area and hence, the rental income. For example, it is estimated that if the building walls in Rockefeller Center, New York City, had been made 4½ in. thick instead of 10½ in., $450,000 more rent would be collected annually.

In most cases, the code requirements for thick walls are based on 19th Century construction practices. Until 1884, when the 10-story Home Insurance Building was erected in Chicago, providing a near approach to skeleton-frame construction, all buildings had load-bearing walls. In the following years, load-bearing walls for multistory structures were made obsolete by development of the skeleton-frame building, in which the floor system carries the walls and transfers the load to columns. In the 20th Century, larger and larger portions of the walls were replaced by windows. But code writers, influenced by past practices, tended to retain requirements for thick masonry walls, although lighter, thinner walls that could serve as adequately had been developed.

Even experienced engineers and architects hesitate to cut the mental ties with the past. Some years ago, I visited an architect who had offices on the 20th floor of a New York skyscraper. We were discussing wall construction when the possibility of walls only 2 in. thick was proposed. He declared flatly that such a wall would never withstand the wind pressure on a building such as we were in. And at the time, he was looking out over the city through a 6x12-ft. wall of glass—the height of a man and the width of a fair-sized bedroom—but only ⅜ in. thick.

The concept of thin, lightweight curtain walls is almost as old as that of skeleton frames and as logical a development. Three trends are definitely discernible at present:

1. Adaptation to urban structures of metal-pan construction as used in industrial buildings, tending to replace masonry entirely.

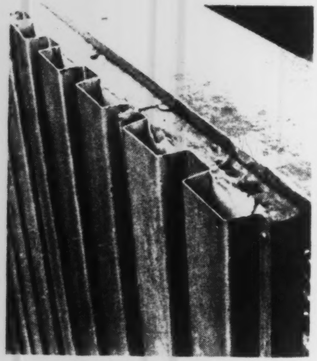
2. Modification of traditional masonry walls by using a face panel of metal or a clay product. These are curtain walls carried by the floor system, as in conventional multistory

LIGHTWEIGHT CONCRETE backs up a cast aluminum facing in the walls of an office building for the Aluminum Company of America. (Alice Cook photo)

skeleton-frame construction.

3. Use of a deep-truss wall that carries the floor system and transfers the load directly to the columns—a trend that is barely getting started.

Outside of areas governed by municipal building codes, lightweight walls have been extensively used in industrial construction. Where it is possible to apply the same engineering principles—but not necessarily the same materials or construction methods—to multistory "fireproof" buildings within our larger cities, we could today have a close approximation of the wall we may see in office buildings 25 years hence.



METAL PANELS inclose an office building in Garden City, L. I.

The metal panel walls now used for large industrial plants, if adapted to first-class multistory office buildings, would be ". . . . immune to destruction by fire originating either inside or outside the buildings . . . ." However, they cannot be used under most codes. Why? Because they are not 8 in. of masonry.

Fire test unrealistic

The recently amended New York City building code now permits walls of materials other than masonry and no longer specified minimum thickness—provided the new construction receives a two-hour rating under the American Society for Testing Materials fire-test procedure. While this amendment is of considerable help in enabling new materials and methods to be used, the temperature limitations in this test are still a serious handicap.

Most of the steel panel systems used for industrial buildings during the war and since could be adapted easily for use in "fireproof" multistory office buildings were it not for the fact that in the fire test the temperature rise on the side of a panel away from the fire would average 250 deg. F. in less than the prescribed two hours. No such requirement limiting temperature rise, however, is specified for windows—which may replace 80 percent of the wall area and which may reach 1,700 deg. F. in a few minutes Also, codes permit the temperature of columns to reach 1,000 deg. F. before it is considered dangerous.

The situation is analagous to allowing roof sheathing that will carry only 5 psf. but requiring the roof trusses to take the equivalent of 60 psf. with a safety factor of five—or 300 psf.—and the columns to support combined live and dead load with a safety factor of two.

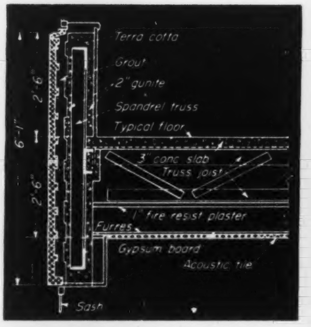
Some metal-pan systems are being modified to meet the two-hour test. In the process, however, they lose much of the simplicity of their present designs. Also, unless the thickness of the panel is increased, it is necessary to reduce the overall insulating value, since resort must be had to heavier core materials containing moisture. Because the water, which is undesirable in insulation, is converted to steam in a fire test, these materials resist temperature rise much better than glass-fiber, cellular-glass, or other high-grade, insulating materials that have little or no moisture content. Hence, the present ASTM test procedure, as specified by building-code authorities and used by the National Board of Fire Underwriters, actually encourages inferior wall insulation in multistory "fireproof" structures.

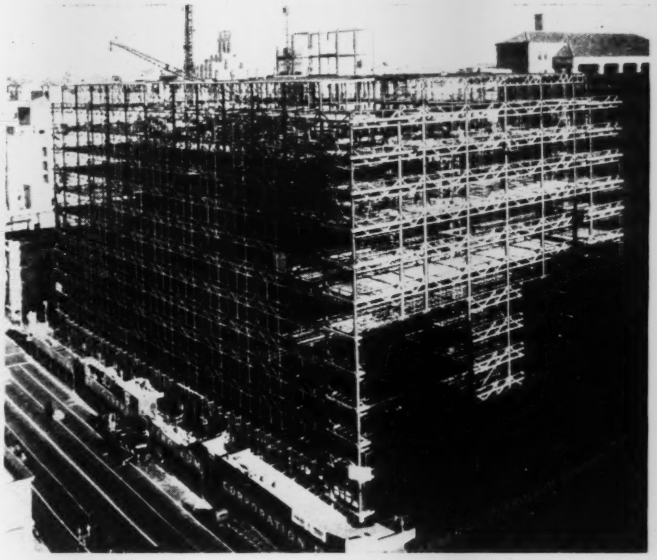
• What about appearance?

Two questions that frequently arise in connection with the use of industrial panels in multistory office buildings are appearance and permanance.

While the appearance of many of these industrial panels can be greatly improved, some of them are quite satisfactory: A recently completed office building by a leading New York architect has an exterior facing of stone that is such a good imitation of a well-known industrial wall system that a prominent architect having offices in the building thought the exterior wall was the metal system.

As far as durability is concerned, the panels of carbon steel generally used for industrial buildings should not be used for first-class structures unless they are protected with porcelain enamel. As an alternative—and possibly the best method of upgrading quality in the industrial panel system—stainless steel may be substituted for carbon steel. Aluminum has been used for industrial buildings, but because of its low melting point, code authorities will not accept it as a struc-





TRUSSES spanning between the outer columns of the General Petroleum Building in Los Angeles carry the floor and wall loads. (Art. Streib photo)

tural element in a curtain wall in "fireproof" structures. When used, it must be backed with a material that will take the entire lateral wind load and pass the standard fire test.

The orderly evolution of industrial panel walls into spandrels for office buildings appears to be effectively stopped at city limits. Lightweight walls, instead of being developed by engineering design, are now being evolved the slower way from masonry walls. Until we get a more realistic engineering approach to codes, it will be necessary for the architect-engineer to approach the problem of lightweight walls in code-governed areas as a problem of modifying masonry walls.

The first step is obviously the substitution of lighter aggregates in the masonry back-up wall. This has been done in numerous buildings and is well illustrated by the Prudential and General Petroleum office buildings recently completed in Los Angeles. There, lightweight aggregates reduced the dead load by more than one-third. And were it not for unrealistic code restrictions, the total masonry material in the walls could have been reduced in weight and thickness by an additional 50 to 75 percent.

Designed by Wurdeman and Becket, architects, and Murray Erick, structural engineer, the buildings demonstrate two almost diametrically opposite approaches to lightweight wall design. In the Prudential Building, the floor—supported by columns—carries the wall, in more or less conventional manner. In the General Petroleum Building, the wall—supported by columns—carries the floor.

This deep-truss wall was adopted in Los Angeles chiefly for seismic resistance. Where earthquakes are not a serious problem, traditional steel or reinforced concrete spandrel beams probably will be used during the next 25 years to support the walls, because less thought and less effort with code authorities are involved, although from an engineering and economy standpoint the deep truss is preferred.

The Prudential and General Petroleum buildings are faced with terra cotta anchored to the masonry backup. The walls of the former are 10 in. over-all and these of the latter 12 in. In New York City, the thickness of these walls might be reduced to 4 or 5 in. Other materials and designs could produce a wall 2 or 3 in. thick to meet New York requirements.

Where codes, as in New York City, are amended to permit walls of less than 8-in. thickness, methods of reinforcement are developed to enable 2 or 4-in. lightweight masonry to withstand the lateral wind-load test. The first method tested for approval under the amended New York code consisted of flat, strap iron reinforcing, which was placed in the joints between adjoining 16-in. blocks of lightweight concrete. In another system submitted for approval there, the waterproofing and reinforcing of a 3-in. lightweight pumice-concrete block wall was obtained by bonding the stainless steel spandrel face to the masonry backup. Other designs called for a 4 or 5-in. thick wall of cellular-glass insulation sandwiched between two thin concrete slabs, to one of which an exterior facing of stainless steel is bonded.

These examples are about as far as it will be possible to go with masonry.

In contrast, development of the deep-truss wall offers almost unlimited possibilities. For example, in one type proposed, a stainless steel compression member forms the window sill, intermediate shelf angles support the floor, and a tension member acts as the window head of the story below. The truss may be encased in noncombustible insulating materials, or inclosed in a noncorrosive envelope.

In addition to the advantages of light weight and small thickness, this construction decreases the unbraced length of columns, permitting smaller members to be used.

In a second type, a noncorrosive metal envelope, attached to its insulation core to form a structural laminate, has sufficient strength and rigidity that the truss for carrying the floor load may be eliminated. The laminate forms a deep box girder, being both wall and support for the floor.

Both the truss and the deep girder offer worthwhile opportunities for over-all reduction in the weight-stiffness ratio of buildings that will not be ignored indefinitely.

AN ARTICLE TO MOLD THE FUTURE

Fitting Highways to the Driver

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SIGNIFICANT ADVANCES are being made in the design of highways as a result of recent studies of highway traffic movements. Many highways today are being tailored to fit the drivers and the vehicles they operate. Tomorrow's highways must all be designed with this requirement in mind.

This more logical approach to the design of those elements of the highway that a driver sees and which influence his performance at the wheel has been made possible by extensive studies conducted by the Bureau of Public Roads, generally in cooperation with various state highway departments. The better knowledge of the dynamics of highway movement produced by those studies is being applied effectively to what are commonly called the geometric elements of highways—the alignment, profile and horizontal dimensions of the cross-section, including surface and shoulder widths and clearances to obstructions.

The degree to which these new dynamic concepts are intelligently applied in combination with studies of traffic growth will determine in large measure the efficiency and safety of our future highways.

Effect of driver behavior

As an example of how the dynamic concept influences highway design, consider the traffic lane width required for the safe operation of tractor-semitrailer combination units. As these combination units travel around a curve, the rear wheels do not follow in the same path as the front wheels and the unit in effect occupies a greater width of pavement than when on a straight-of-way. The difference in the two widths is called the "off-tracking." For a certain degree of curvature, it is comparatively easy to calculate the actual off-tracking for a unit with a certain wheel base. For safe highway design, however, the important thing to know is how the unit is actually operated as a result of how much the driver THINKS that it off-tracks.

Proper allowance must be made in the design of curves to accommodate the combination units in the manner in which they are driven rather than in the manner that they should be driven, if safety is to be provided for the other vehicles on the highway. Likewise, it is necessary to determine under actual highway conditions many other features relating to how people actually operate their vehicles, rather than how they should operate them, in order to provide safe and efficient highway facilities.

Each individual driver operates his vehicle in a somewhat different manner than any other driver even under similar circumstances. It is, therefore, impossible to predict what an individual driver will do under a given highway condition. Driver behavior en masse, however, takes on very definite characteristics, and as a result certain principles of traffic flow have been developed, which in effect are similar to the various laws of physics in that the performance of drivers can be predicted with a high degree of accuracy.

Trends in driving speeds

The trend in driving speeds has an important bearing on future highway design. In 1925 only the high-priced cars available to the public were capable of exceeding 60 miles per hour. Today, the average low-priced car can exceed 80 mph., and there is no doubt of the possibility of designing vehicles capable of even higher speeds.

Other factors, however, including personal traits or limitations of the drivers, increased use of the airplane for long-distance travel, and economic considerations of highway design, indicate that, although average speeds on our main highways will continue to increase, the increase will be the result of a reduction in the number of vehicles traveling at the lower speeds rather than an increase in the top speeds. This will be the result of providing highways with controlled access and the elimination of dangerous intersections at grade.

Wide range of speeds

Fig. 1 shows that on most of our main rural highways individual speeds range from 21 to 62 mph., with 12 percent of the drivers exceeding 50 mph and 32 percent traveling less than 40 mph.

On our highest speed highways of modern design, with cross roads separated and no limitation on speed except the desires of the individual drivers, about 40 percent of the drivers travel over 50 mph. and 17 percent travel slower than 40 mph. Only a scattered few travel faster than 60 mph., a speed at least 20 mph. slower than the speed capacities of the vehicles. This is for conditions of low traffic density when the only limits on speed are the drivers' own idiosyncrasies and inhibitions.

The dashed line in Fig. 1 indicates a distribution of speeds most likely to be typical of future conditions on rural highways of modern design. The average speed is 56 mph., 8 mph. faster than on our modern highways at the present time and 13 mph. faster than on our average highways, without an increase in the top speeds

The lack of adequate highways is

often given as the reason that everyone does not travel faster than 50, 60, or even 70 mph. There are, however, long level tangent stretches of highway in the West and Middle West where sight distances are practically unlimited and other features of the highway are most favorable for high speed. Even under these conditions, many drivers prefer to travel below 50 or even 40 mph. and few exceed 60 mph. This does not substantiate the theory that there is a need for highways designed for speeds of 80 or 100 miles per hour. There is however, a great need for rural highways that will safely accommodate travel speeds up to 70 mph. during light traffic densities, and speeds of 45 to 50 mph. during all but a few peak volume periods of the year.

In urban areas the need is principally for facilities that will safely accommodate speeds up to 50 mph. during light traffic and on which 30 to 35 mph. will be possible with safety during most of the periods of peak flow. This is the basis for the standards of future construction on the National System of Interstate Highways, which includes only one percent of the nation's rural mileage of roads and streets, but carries approximately 20 percent of the rural traffic, and connects nearly all of the cities having a population over 50,000.

Effect of traffic volume

One of the characteristics of traffic flow which has a most important effect on highway design is the decrease in average speeds with an increase in traffic volume on any given highway facility. Fig. 2 shows the average speeds at different traffic volumes on tangent sections of two-lane highways. As the traffic volume increases, there is a uniform decrease in the average speeds until, at a volume of 2,000 vehicles per hour (the possible capacity of a two-lane highway with no curves or restrictive sight distances) the average speed corresponds to the speed of the slowest group of drivers. It is therefore obvious that if two-lane highways are to be provided on which drivers have a reasonable freedom in the selection of their operating speeds, the engineer cannot expect such a highway to furnish satisfactory operating conditions at volumes approaching the possible capacity of 2,000 vehicles per hour. In fact, it has been found from extensive studies that operating conditions are not satisfactory for the average driver on the most perfect two-lane rural highway when the total traffic volume exceeds 800 vehicles per hour, of which 10 percent are trucks and busses, the usual percentage of such vehicles during peak traffic flows.

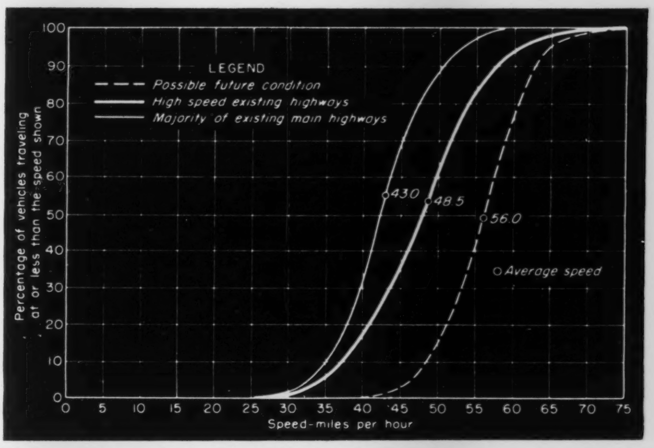


FIG. 1. FREQUENCY DISTRIBUTION of travel speeds of free moving vehicles on level tangent sections of two-lane rural highways.

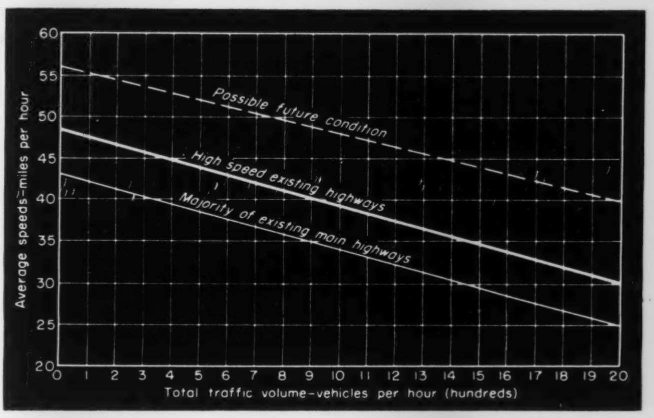


FIG. 2. AVERAGE SPEEDS of vehicles on level tangents of two-lane rural highways.

The effect that various traffic volumes have on safe operating speeds on two-lane highways is illustrated by Fig. 3, which represents sections free from intersections at grade and free of short sight distances. A driver desiring to travel at 70 mph. can travel at this speed 100 percent of the time as long as there is no other traffic on the highway. When there is other traffic on the highway, however, he soon overtakes a vehicle traveling at a slower speed and unless there is a space between vehicles in the opposing traffic lane of sufficient length to permit him to pass, he must reduce his speed until such an opportunity does occur, after which he can again increase his speed to 70 mph. At a total traffic volume of 200 vehicles per hour, it will be possible for the driver to average 61 mph. if he takes full advantage of his opportunities to pass the slower drivers.

At a traffic volume of about 550 vehicles per hour he will not be able to travel at 70 mph. because before he reaches this speed after passing one vehicle he will have to start slowing down to avoid a rear end collision with the preceding vehicle traveling in the same direction or a head-on collision with oncoming traffic in the opposing traffic lane. His average speed will then be only 51 mph. Likewise, a driver trying to travel 60 mph. can maintain this speed 100 percent of the time when there is no other traffic, and his average speed will drop to 54

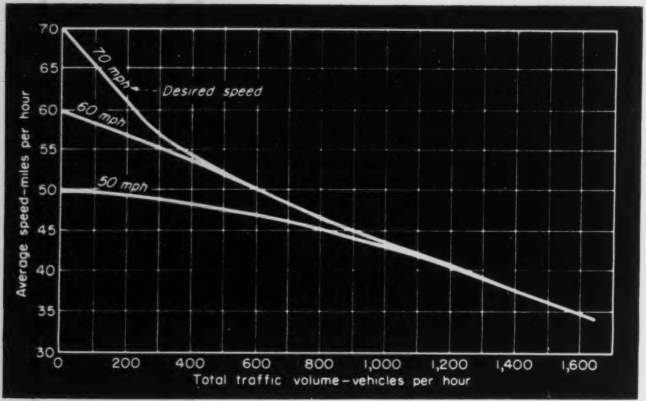


FIG. 3. **AVERAGE SPEED FOR DRIVERS traveling at their desired speeds whenever possible on a two-lane level highway with no restrictions as to distances.**

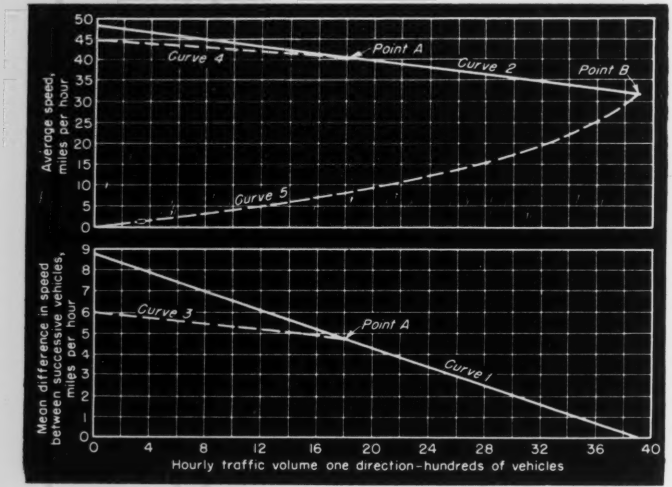


FIG. 4. **SPEEDS AND SPEED DIFFERENCES on a typical four-lane divided highway.**

mph. when the traffic volume is 400 vehicles per hour. He cannot at any time attain this speed when the traffic volume is in excess of 850 vehicles per hour. Also, a driver trying to maintain a speed of 50 mph. can average 46 mph. with a traffic volume of 750 vehicles per hour, but when the traffic volume reaches 1,400 vehicles per hour, his average speed will be only 38 mph.

For all practical purposes, the speeds for the 60 and 70-mph. drivers are the same when the traffic volume is in excess of 300 cars per hour, and these drivers can travel no faster when the volume exceeds 1,000 vehicles per hour than a driver who is content to travel at a top speed of 50 mph. It is obvious, therefore, that two-lane highways will not provide operating speeds in the neighborhood of 60 or 70 mph. except at extremely low traffic densities.

Increasing lane capacity

A 4-lane divided highway will accommodate much higher traffic volumes per lane than a two-lane highway. Fig. 4 has been prepared to illustrate traffic conditions during various hourly flows on the two lanes used by traffic traveling in one direction on a four-lane divided highway. Curve 1 represents the relative freedom from congestion in terms of the difference in speed between successive vehicles. At extremely low traffic flows, each driver can travel at his desired speed, and the mean difference in speed is 8.8 miles per hour. As the traffic density increases, each driver is influenced more and more by the speed of other vehicles on the highway until, at a traffic volume of about 3,850 vehicles per hour, all drivers must travel at the same speed, which is the speed of the slowest drivers. Under these conditions the mean difference in speed becomes zero, indicating that the possible capacity of the two lanes has been reached.

Speed limits have minor effect

With an enforced speed limit of 50 mph., the speed differences at the lower traffic volumes would be as shown by Curve 3, indicating that, at traffic volumes above 1,800 vehicles per hour (Point A), the traffic density had a greater effect on speeds than the enforced speed limit.

Curve 2 of Fig. 4, in the upper part of the chart, shows the average speed for all vehicles at different traffic flows without a speed limit, whereas Curve 4 shows the effect, at the lower traffic volumes, of the enforced 50-mph. speed limit.

Curve 5 shows the slowest speed at which the vehicles can be operated to attain the various hourly flows. Thus, with a flow of 1,200 vehicles per hour, the normal speeds would average 43 mph., but the vehicles could slow down to 5 mph. and still maintain the flow of 1,200 vehicles per hour. To attain a flow of 3,850 vehicles per hour, (the possible capacity) all drivers must operate at 32 mph. In case just one driver slows down to a lower speed, the highway will immediately become completely congested and some cars will come to a complete stop. The distance between curves 2 and 5, therefore, represents the relative safety factor from complete congestion at the various hourly traffic flows.

Limits on lane capacity

This and other criteria that have been developed place the practical capacity of a modern four-lane divided rural highway at 1,000 passenger cars per hour for each lane in the direction of the heavier flow, or a total of 3,000 passenger cars per hour with two-thirds of the traffic in the one direction, the normal distribution by directions during peak periods. At this volume, drivers who so desire can safely average 45 to 50 mph., with an average speed of 40 mph. for all traffic.

On urban expressways or freeways

where drivers are content to average 35 to 40 mph., lane capacities of 1,500 passenger cars per hour, or a total capacity of 4,500 passenger cars per hour for a four-lane divided roadway are practical with two-thirds of the traffic in one direction.

Thus, a four lane divided highway will accommodate from 3½-to 5-times as much traffic as a good two-lane road.

From these considerations it becomes apparent that this type of a highway will replace the two-lane roads that now are loaded beyond their practical capacities as rapidly as funds for new construction become available. As a result, accidents at these locations will be cut to less than half their present rate.

Better provision for passing

The large majority of the road mileage through rural areas will never carry sufficient traffic to justify more than a two-lane highway. If accident rates on these roads are to be reduced and a safe economical transportation system provided, much of the two-lane mileage must be rebuilt or improved to standards found to be necessary through the extensive driver behavior and motor vehicle performance studies. Of these standards, those which relate to sight distance, or the length of roadway visible to the driver when the view is unobstructed by other traffic, are of major importance. The sight distances, which determine to a large degree the operating conditions on a highway, are of two types—stopping sight distance and passing sight distance.

Stopping sight distance is the distance required by a driver of a vehicle, traveling at a given speed, to bring his vehicle to a stop after an object on the roadway becomes visible. This sight distance is necessary at all times on all types of highways.

Passing sight distance is the minimum sight distance that must be available to enable the driver of one vehicle to pass another vehicle safely and comfortably without interfering with the speed of an on-coming vehicle, should it come into view after the passing maneuver is started.

While stopping sight distance is necessary continuously on all types of highways, passing sight distance is necessary only on two-way roadways with two or three lanes.

New data on sight distances

Recent studies have shown that if adequate stopping sight distance are to be provided for all passenger cars other than the 10 or 15 percent with brakes in very poor condition, stopping sight distances 20 to 30 percent longer than those used for highway designs in the past must be provided. Trucks and combination units require much longer distances in stopping than do passenger cars. A stopping sight distance which is adequate for a passenger car traveling 70 mph. is not adequate for combination units with normal loads traveling above 50 mph.

A driver on a two-lane road must occupy the lane normally used by oncoming traffic to pass a slow moving truck or passenger car. Where the necessary sight distances for passing are not available, the drivers desiring to pass are prevented from executing the maneuver in much the same way as if the left lane carried traffic.

The necessary alinement and profile of a highway to provide adequate passing opportunities at various total hourly flows was only recently determined as a result of extensive research on the manner in which passing maneuvers are performed, the frequency of their occurrence with various volumes of traffic, and the space between oncoming vehicles that drivers take full advantage of to perform passings. These studies have shown that the greatest need is for sight distances which will permit vehicles traveling under 50 mph. to be passed safely. Such sight distances should be from 1,500 to 2,000 ft. Where sight distances of 1,500 to 2,000 ft. are not continuously available throughout the length of a two-lane highway, the percentage of the highway on which the sight distance is 1,500 ft. or more can be used as a criterion of the highway's practical capacity. Reductions in capacity caused by sight distances of less than 1,500 ft. are shown in the accompanying table.

Through the application of this information, it will be possible for engineers to provide an alignment and profile, when constructing new two-lane highways or when reconstructing existing two-lane highways, that will be consistent with the traffic demand and the desires of the drivers that will use the highway. In many cases it will be less expensive to provide the proper design now that an accurate criterion is available than it would be to follow the less scientific approach which has been used in the past.

Other expected improvements

Other features of geometric design, which will be evident to motor-vehicle operators as they travel over rural highways of modern design, are the wider traffic lanes, more adequate clearances to obstructions such as retaining walls, bridge piers and bridge railings, wider shoulders that are safe to use under all weather conditions, fewer intersections at grade, better control of access, and more effective signing and pavement marking. These features, which improve driving comfort and are necessary for safe, efficient transportation, can also be justified economically. A 9-ft. traffic lane on a four-lane highway, for example, has only 81 percent of the capacity of a 12-ft. lane. On a two-lane highway it has only 70 percent of the capacity of a 12-ft. lane. Obstructions located near the edge of 12-ft. traffic lanes reduce the effective capacity of those lanes by approximately 15 percent. At the edge of narrower lanes, the effect is even more severe.

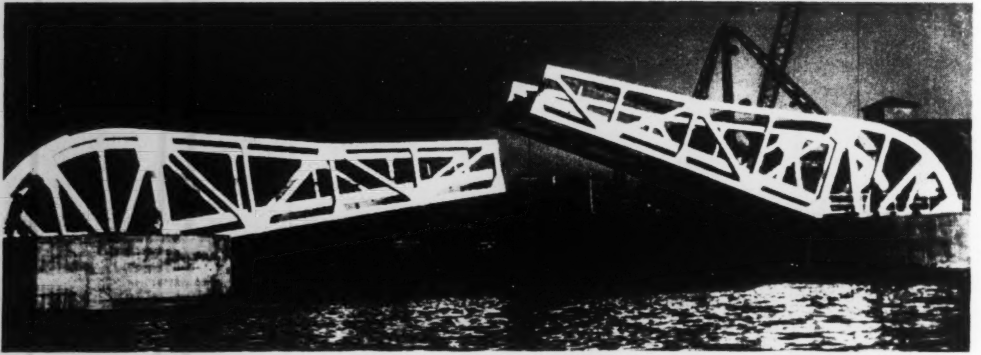
Narrow shoulders reduce the effective width of a traffic lane by causing vehicles to travel nearer the center of the pavement. The greatest detrimental effect on capacity of inadequate shoulders, however, is created when disabled vehicles, of which there is an average of at least one for every 10,000 vehicle miles, are unable to park clear of the traffic lanes. One disabled vehicle can reduce the capacity of a highway during peak periods by as much as 60 percent. Shoulders that will accommodate disabled vehicles and that may be used by moving vehicles in cases of emergency during any weather condition are essential for safety on highways.

RELATION OF CAPACITY TO SIGHT DISTANCE ON TWO-LANE ROAD

Percentage of highway with sight distance restricted to less than 1,500 ft.	Practical capacity in passenger cars per hour	
	For operating speeds[1] of 45 to 50 mph.	For operating speeds[1] of 50 to 55 mph.
0	900	600
20	860	560
40	800	500
60	720	420
80	620	300
100	500	160

[1] Average speed of drivers trying to travel at maximum safe speed.

AN ARTICLE TO MOLD THE FUTURE



A 60 PERCENT WEIGHT SAVING over an equivalent steel structure is credited to this aluminum bascule at Sunderland, Eng., first movable type bridge to be built of this metal. (British Combine Photo)

How To Design Aluminum Bridges

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The availability of aluminum as a structural material is a modern addition to the resources of the bridge engineer. It opens up new possibilities in the attainment of longer spans. It offers new opportunities for the economical reconstruction of old spans to carry the present-day, heavier loadings. It is thus a material to be reckoned with for many future jobs.

Structural aluminum provides a material with one outstanding advantage over carbon steel and silicon steel—greatly lower weight (about one-third that of steel) for equal strength. This advantage, however, must be balanced against the higher cost of aluminum alloy materials. The comparative costs (at 1949 prices) per pound of silicon steel and structural aluminum may be roughly analyzed as follows:

	Silicon Steel	**Aluminum (14S-T6)**
Base Price	3¢	34¢
Silicon Extra	1	—
Fabrication	5.5	16
Freight	1.5	2
Erection	7	13
	18¢	65¢

The present pound-price ratio is thus 3.6. Since the weight-ratio of the two materials is 2.8, the present relative cost of structural aluminum *per square in. of cross-section* is 1.29 compared with silicon steel (and 1.45 compared with carbon steel at 16 c. per lb.). With basic unit tensile stresses of 18,000, 22,000 and 24,000 for carbon steel, aluminum and silicon steel, the present relative cost of structural aluminum *for equal tensile design strength* is 1.41 compared with silicon steel (1.19 compared with carbon steel). Further developments may bring this ratio still closer to unity. It should be noted, however, that there are useful applications where the saving from weight or dead-load reduction outweighs the price differential.

Aluminum alloys recommended

The preferred high-strength aluminum alloys now available for use in bridge construction are:

Plates—Alclad 14S-T6 or R301-T6.

Structural shapes—14S-T6.

Pressure driven rivets (cold) A17S-T3.

Hammer driven rivets (hot)—53S-T41.

For plates and shapes, the guaranteed minimum tensile strengths vary from 60,000 to 68,000 psi, and the guaranteed minimum yield strengths from 53,000 to 58,000 psi. These variations in physical properties correspond to differences in metal thickness and in the method of production.

The average ultimate shear strengths of the rivets are 33,000 psi for the cold-driven and 24,000 psi for the hot-driven types—low as compared with steel. A new alloy, XB77S, for hot-driven rivets will, however, have a shear strength of 33,000 psi one-half hour after driving and of 42,000 psi after three months.

Even with present rivet stock, large size rivets ($\frac{7}{8}$-in.) of aluminum alloy are supplanting prior use of steel rivets. Cold driving is generally preferred because of improved shear strength and reduced costs. Flat or slightly conical heads are preferred.

The recommended lower-strength aluminum alloy (comparable to carbon steel in strength) now available is 61S-T6, with typical tensile strength of 45,000 psi and yield strength of 40,000 psi. Copper is the principal alloying element for 14S, while a combination of magnesium and silicon is used in 61S.

A new product, Alclad, consists of plates with a 14S core and surface sheets of an alloy equal to 61S in resistance to corrosion. In a welded plate girder bridge at Massena, N. Y. (ENR Nov. 28, 1946) webs and cover plates are of Alclad. The applications of Alclad surface to rolled and extruded shapes has been tried only experimentally as yet.

For both alloys, 14S-T6 and 61S-T6, the yield strength is between 85 and 90 percent of the ultimate tensile strength. (For aluminum alloys, as for other materials without a sharply defined yield point, the yield strength is defined as the stress which produces a plastic strain or permanent set of 0.2 percent).

The yield strength and the ultimate tensile strength are jointly considered in establishing the basic tensile design stresses of 22,000 psi for 14S-T6 and 16,000 psi for 61S-T6.

Governing considerations in design

For the designer in structural aluminum, it is not sufficient to design as in steel, with only the unit stresses changed. Rule-of-thumb designing cannot be used. A new and independent reappraisal of all of the usually accepted conventional limitations is required.

What is a logical restriction of deflections? What is the true probability of maximum loads and of conditions of fatigue? What is the effect of compounding reductions of dead weight on the economic design and form of structure? How will the altered relation of material cost to labor cost modify economic design? How will the lighter weight for transportation and field handling affect design? Why should there be a limitation on minimum thickness in a corrosion resistant material? Will special shapes, available by extrusion processes, save cost? Will tubular or box sections be economical?

These and similar questions need to be effectively answered by the engineer dealing with structural aluminum if he is to obtain the potential savings in cost and weight. Following are some of the considerations that will affect his design.

Economy of Material—In structural aluminum the pound price of the metal outweighs the cost of fabrication and erection. The primary emphasis, therefore, should be placed on saving weight rather than on saving fabrication cost. Thus, where designs in steel would favor the use of plate girders for the spans, a truss design is usually more economical in the case of aluminum. Similarly, trussed floorbeams may advantageously be used in lieu of solid-web floorbeams. Minor members and details should be carefully designed and proportioned to take advantage of possible weight saving without impairing strength.

As further measures toward securing maximum economy of material, continuity of main and floor members and stress participation by floor and bracing members should be utilized wherever practicable.

Bridge shoes and similar heavy detail parts may advantageously be made of steel, where the latter can be insulated from the lighter aluminum alloy members by fillers of pure aluminum.

Weight Saving—The weight ratio between steel and aluminum structures depends upon the type of structure, the span length, and the required performance. As the span length increases, the dead weight becomes increasingly the major part of the total load to be carried, so that any weight saving becomes multiplied in effect.

For a small bridge, such as a 50-ft. highway span, the adoption of aluminum will save 50 to 60 percent of the structure weight. For a span of 600 ft., the weight saving may be 65 to 70 percent. In the longest spans, where the dead weight becomes the governing load to be carried, the savings may approximate 80 percent.

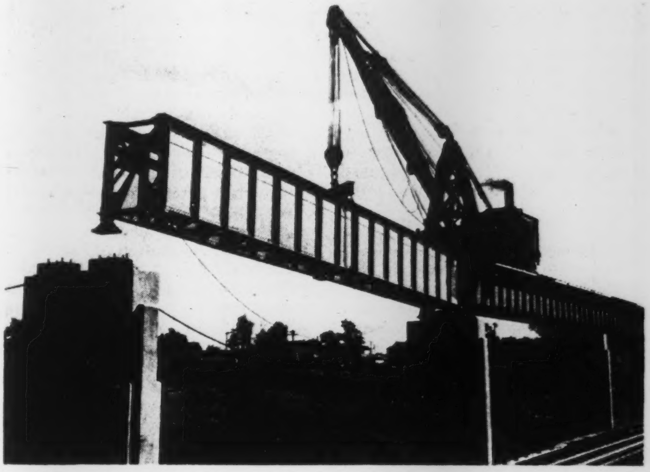
At the present pound-price ratio of 3.6 for aluminum versus steel, a reduction of 72 percent in weight of structural metal would be required for equal first cost. However, other advantages of aluminum may reduce the weight saving necessary for determining its adoption.

Towers and other supporting structures in which compression is the principal stress may preferably be built of steel, using aluminum alloy for the spans (where weight saving is more important). As a general principle, the more remote any portion of the structure is from the final foundation supports, the more important it becomes to reduce its weight (since other parts of the structure are affected by it), and therefore the greater will be the economic justification for building it of aluminum. Suspended floors, suspended spans, arch decks, and similar bridge parts offer the most advantageous applications of the lighter metal.

Relative Labor Cost—As hourly wage rates increase and the cost of fabrication and erection rises relative to the cost of material, the importance of initial material prices decreases. This change in the relative labor cost reduces the total price ratio, and favors the increasing application of aluminum in overall economies.

Lower Modulus—The lower modulus of elasticity of structural aluminum (10,300,000 as compared to 29,000,000 for steel) needs to be considered as affecting the type and proportions of the span as well as the design of compression members, compression flanges and girder webs. An increase in the usually-accepted depth ratios of the various span types may be desirable to reduce deflections, also for economy.

For compression members, the lower modulus of elasticity yields an increased reduction factor for slenderness ratio. For l/r under 72, a plotted column curve is used, from which design stresses can be read off. (The Committee on Design in Lightweight Structural Alloys of the A.S.C.E. Structural Division is developing, for alloy 14S-T6, a column curve based on the tangent modulus formula with a cut-off at 22,000 psi). For higher l/r, the Euler buckling governs, reduc-



AN ENTIRE ASSEMBLED SPAN of structural aluminum is set by a locomotive crane on a bridge at Massena, N. Y. The weight was 53,000 lb. as compared to 128,000 for the identical span (97.5 ft.) in steel upon which the crane rests and which had to be erected piecemeal—a girder at a time plus the cross-frames.

ing the unit stress to values given by a formula of the form:

$$74{,}000{,}000\ r^2/l^2$$

Most efficient use of aluminum alloy in compression can be made in members with values of l/r below 60. The use of members of higher l/r should be limited to those carrying comparatively light stresses. The sections of compression members should, therefore, be selected with the material disposed to yield maximum values of the radius of gyration. This suggests the use of box sections for compression members as most efficient in use of material, producing maximum stiffness, as well as for attractive appearance. Maintenance objections to box sections are minimized in aluminum.

NEW DECK OF ALUMINUM for an old bridge. This pioneer structural aluminum application was made on the Smithfield St. Bridge at Pittsburgh in 1933, and reduced the dead load one ton per lineal foot.

Continuity should be used wherever practicable in order to secure end restraint for the compression members or elements. The extensive utilization of continuity for stringers and floorbeams as well as for main members is indicated.

The same considerations justify the more extensive use of intermediate stiffness in compression members and girders in order to reduce the necessary thickness of the main material to resist buckling.

Minimum Thickness of Metal—Advantage may be taken of the high corrosion resistance of structural aluminum by reducing the minimum thickness of metal as compared with practice in steel. Since the fine film of oxide initially formed on aluminum effectively arrests further corrosion, the necessity for providing additional metal thickness to take care of corrosion is far less important than for steel. In many locations there is no need for any corrosion allowance. The recommended minimum thickness of metal for bridges of structural aluminum is $\frac{3}{16}$-in. for main members and $\frac{1}{4}$-in. for all other parts, except fillers. This appears to be a reasonable limitation in order to prevent the use of material that is too thin to resist incidental damage.

Corrosion Resistance—Aluminum alloys will withstand atmospheric attack to a remarkable degree if they are properly selected and properly installed. The design details should not, of course, provide pockets or crevices where moisture will collect and be retained.

Electrolytic corrosion and damage from highly alkaline solutions, however, must be guarded against. Contact with steel, copper, lead, nickel or certain other heavy metals should be avoided; caulking or fillers of pure aluminum are useful expedients. Likewise, direct contact with concrete, wet wood, asbestos or other absorbent materials should not be allowed. Although the magnesium silicide type of alloy (61S) does not, as a rule, require painting on exposed surfaces, it is good practice to protect surfaces at points of contact of dissimilar materials so as to exclude moisture; zinc chromate, bituminous paints, or suitable mastics may be used.

Aluminum surfaces must not be expected to retain their initial bright appearance. They will become film-covered and dirty, like any other material, and certain atmospheres may cause mild surface pitting. A bright appearance can be maintained by periodic cleaning but, even if this is neglected, the amount of surface damage will normally be negligible over a long period of years.

Stress Concentrations—The high ratio of yield strength to ultimate strength in heat-treated aluminum alloy restricts the redistribution of excessive local stress, and makes it extremely important to avoid stress concentrations. Reentrant corners, eccentric loading, fabrication inaccuracies, inadequate details, concentrated point loadings and unrelieved erection strains should be avoided.

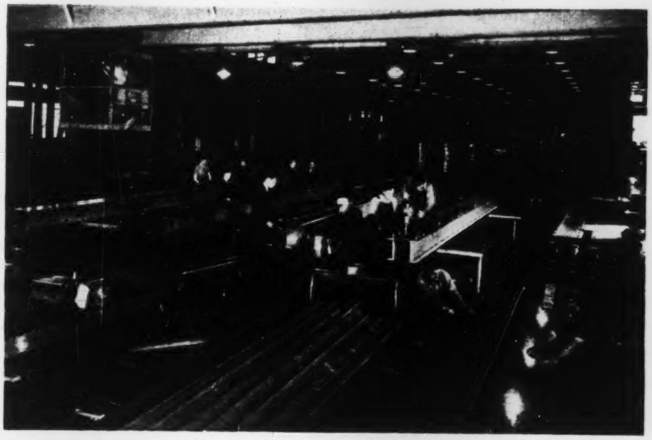
In the Smithfield St. Bridge at Pittsburgh (ENR Nov. 23 and Dec. 28, 1933) where the first extensive application of structural aluminum to bridges was made, some of these lessons were learned by experience. Some of the street railway ties came to bearing only on the extreme toe of the top flange angles of the track stringers, which caused excessive local stressing of the angle legs as cars passed. Fatigue cracks developed at the vertex of the angles in a few locations, requiring repairs and better realignment of the ties.

Another fault arose from a too-rigid connection between track stringers and floorbeams. Excessive local bending resulted in fatigue cracks in some of the clip angles. When this connection was "softened up" by removing some of the rivets from the clip angles and inserting shelf plates under the ends of the stringers, the local stresses were reduced and the trouble stopped.

Repeated and Alternating Stresses—For aluminum alloy 14S-T6, the endurance limit for 500,000,000 cycles of completely reversed stress is 18,000 psi. In the useful life of a bridge, the probable number of maximum stress repetitions or reversals would be a much lower figure, certainly under 2,000,000 cycles. For 2,000,000 cycles of complete reversal of stress on smooth specimens the fatigue strength is 25,000 psi.

In design, due consideration should be given to stress reversals in proportioning the sections. Discontinuities, such as sharp reentrant corners, should be avoided as they cause a marked reduction in the fatigue life of a member.

Shapes and Plates Available—The range of sizes available in shapes and plates is another factor influencing design. Aluminum alloy plates are rolled in any size likely to be required for girder webs, columns, chord sections and cover plates. For the deck plate girder bridge at Massena, N. Y. (ENR Nov. 28, 1946) plates were rolled 10 ft. wide, $\frac{3}{4}$ in. thick and 26 ft. long, and larger plates are now being made



FABRICATING ALUMINUM MEMBERS for a 290-ft. arch now being erected over the Saguenay River at Arvida, Que. The principal difference from steel fabrication is that care must be exercised in the application of heat. (Dominion Bridge Co. Photo).

available. Present shape sizes range through 8 x 8-in. angles, 15-in. channels and 14-in. wide-flange beams. Deeper beams must now be built up, but larger sizes will be produced whenever the demand justifies the investment in new equipment and mills.

Use of Extruded Shapes—One advantage of structural aluminum is the possibility of securing special shapes made by the extrusion process. This gives the engineer greater flexibility in designing one-piece chord or column sections and other special sections for more advantageous distribution of material for weight-saving and for reducing fabrication costs.

Present available applications of the extrusion process are limited to sections that can pass through a 17-in. diameter circle. As a rule, however, standard structural shapes (as listed in the Alcoa Structural Handbook) should preferably be used because the pound price for such shapes is less than that for special extrusions. The use of special extruded sections is justified where large quantities render the die cost relatively unimportant or where the ultimate in weight saving must be achieved, as in certain military structures.

Larger Assemblies—Because the material is lighter, larger shop-assembled sections can be transported and handled in the field. This affects the design and the detailing toward minimizing or eliminating field splices and connections.

Wind Resistance—The light dead load of aluminum spans requires that greater resistance to wind uplift and overturning be developed in bridge shoes and end details than for heavier steel structures.

Fabrication—In general, less power is required and lighter tools can be used in fabricating structural aluminum than with steel. Field riveting should be minimized in order to take advantage of the higher efficiency (in shear strength and in reduced costs) of the cold-driven shop rivets installed with heavy pressure equipment. Welding should be restricted to low-stressed items, such as fascias, lighting standards, and other architectural features. Flame-cutting is not applicable; ragged edges are produced, with local damage from the heat. Cutting torches and arc welders are replaced by shears, saws, punches, and pressure-riveters.

Plates and shapes not thicker than ½ in. can be sheared. The shapes and plates are clean and true, and light to handle. Mistakes, however, cost more; it is more difficult to straighten curved or buckled plates of aluminum than of steel because of their high yield strength and low modulus. Riveting is slower, but machining and reaming are faster, and the light-weight shapes can be moved by hand without waiting for a crane.

Hot-bending and forming operations require heat-treatment after working, if working temperatures exceed about 400 deg. F. Structural shops sometimes perform moderately severe bends at a temperature of about 400 deg. F. Bevelling of angles and rolling of shapes or plates to curve of large radius can be performed by cold bending.

Temperature Effects—Structural aluminum should not be used where it may be exposed to high temperatures. It has been said that aluminum "likes to be cold." As this material gets hotter it becomes weaker and more ductile. Exposure at 500 deg. F. for one-half hour will permanently reduce the tensile strength of 14S-T6 by 20 percent and of 61S-T6 by 10 percent. The melting point is 950 to 1180 deg. F. for 14S and 1080 to 1205 deg. F. for 61S. For short time exposure, the temperature of the metal is usually substantially below the surrounding environment on account of the high thermal conductivity of aluminum.

Welding—Although welding of structural aluminum is still restricted in application it was used in the M-4 floating bridge, developed by U. S. Army Engineers during World War II. The flooring members were hollow box beams made from two extruded channel-shaped members of alloy 14S-T6. These box sections were assembled by welding, and the ends were closed so that the member would float. The welding was confined to the neutral axis and the ends of the beams, so that the aluminum alloy retained its full strength in locations of maximum stress.

A newly completed and tested military bridge has an all-metal deck of alloy 14S-T6, utilizing special extruded shapes to give maximum strength with minimum weight. Here, again, welding was used for many parts, particularly in building up box sections. The main joints are riveted, using the new high-strength XB77S-W rivet.

Bridge Floors — Aluminum alloy floors for highway and pedestrian traffic offer minimum weight and long life. Designs that have been used to advantage include flat plates suitably supported and special extruded planks, both in combination with bituminous surfacing materials. Open-grid floors and tread plates are advantageously made of aluminum for light weight, for ease of handling, and for corrosion resistance. A recent comparative design study of light-weight floors for a proposed bridge gave the following relative weights:

Timber deck with steel tread plates—32 psf.

Steel grating, sills and stringers—25 psf.

Aluminum alloy grating, sills and stringers—11 psf.

Open-grid floors of aluminum would have multiplied economic advantage in bascule spans and other movable bridges.

Special Details—Corrosion resistance, light weight and availability of extruded shapes make aluminum advantageous for railings, lighting standards, fascias, spandrels, and other architectural features of bridges. For toll houses and service houses, the doors, window frames and sash, roofing, side panels and trim may advantageously be made of sheet or cast aluminum. Aluminum bridge railings may be of simple pipe rail design with cast aluminum posts, or more decorative as may be desired. The basic costs are as little as $10 per linear foot.

Applications to various bridge types

In *plate girder bridges*, much of the web material is inefficiently utilized in comparison with truss designs. This is unimportant in steel, where the cost of the metal is relatively small and the saving in fabrication and erection cost is the governing consideration. In structural aluminum, however, the high base price of the metal is a dominant consideration. Consequently it is difficult for aluminum to compete economically with steel in application to plate girder spans. Moreover, the lower modulus of elasticity adversely affects the stiffness, and the depths of plate girders are limited by the plate sizes available. Accordingly, fixed plate girder bridges do not offer an immediately attractive field for competitive aluminum designs, except where corrosion conditions are unusual.

Aluminum should have a valuable application in comparatively deep and stiff *truss bridges* of long span, where the lighter metal yields a high compounded saving in weight. The reduction in stiffness may be compensated, within limitations, by increasing the depth, but the reduction in working stress below that for silicon steel will partly neutralize the saving in weight.

The use of designs applying as much as possible of the material in tension rather than in compression is even more important than in the case of steel. For a given deformation, the secondary stresses in aluminum truss members will be one-third as great as in steel. An aluminum floor system and roadway may advantageously be used in long spans, since the stiffness of the span proper does not depend upon the floor, and since, moreover, each pound of weight saving in the floor may save several pounds in the trusses of such bridges.

In application of structural aluminum to *railroad bridges*, resistance to deflections and vibrations requires consideration. In the plate girder bridge at Massena, N. Y., designed for Cooper's E-60 loading, the 97.5 ft. aluminum span was made of alloy 14S-T6. Although the weight saving over the similar steel spans was 58 percent, the cost (at 1946 prices) was 70 percent more than steel.

The completely assembled span was shipped from the plant near Pittsburgh to Massena (575 miles) in one piece, unloaded at the site and set in place in a few hours. For the steel spans of the same bridge, the separate girders had to be shipped and set individually, and the cross bracing assembled and riveted in the field, requiring two days per span.

The maximum deflections under static load were 0.61 in. for the steel spans and 1.53 in. for the aluminum span, but under moving load these deflections increased only 14 percent for the aluminum and 13 percent for the steel. No adverse effects, either physical or psychological, were observed from the increased deflection. The vibration characteristics of the aluminum span were studied, and no tendencies toward resonance under the hammer blows of the unbalanced locomotive drivers were observed.

Structural aluminum offers outstanding advantages in application to *movable bridges*, particularly bascule and vertical lift spans. Each pound of weight reduction in the span to be lifted will save a pound in the counterweights of a lift span and up to three pounds in the counterweight of a bascule span, with corresponding savings in the structure of the counterweight supports or towers, together with multiplied dollar savings in the operating machinery and equipment.

The savings in counterweight metal and space are valuable, in addition to the savings in tower steel, cables, machinery, and possibly in the substructure. In a study for a 300-ft. lift span, the indicated saving in weight of the lift span was 70 percent, with an equal saving in the counterweights, plus a 50 percent saving in the expensive items of cables and machinery. For a double-leaf 121-ft. aluminum bascule span recently completed at Sunderland, Eng., (ENR Dec. 16 1948) a weight 40 per cent that of an equivalent steel span was achieved.

In application to *cantilever bridges*, structural aluminum offers the greatest multiplied saving if used in the suspended span. This weight saving reduces the stresses in the cantilever arms and in the anchor spans. Some economy, though not as marked, may also result from use of the lighter metal in the cantilever arms, since this will also relieve the stresses in the anchor spans. In the anchor spans, however, added weight is often required to eliminate or reduce stress reversals, so that a reduction of their weight may not be desirable.

Aluminum does not appear to have its best application in *arch bridges* of considerable span, since the dominant stress is compression. Moreover, in long or slender plate girder arches, the buckling load is reduced to about one-third that for steel, by reason of the ratio of the moduli of elasticity. On the other hand, the reduction in dead load tends to compensate for the reduction in buckling load since, in an arch, the dead load thrust is deducted from the buckling load in computing the stiffness factor. In any case, the deck or suspended roadway of a long span arch may often advantageously be built of aluminum. It is to be noted that a 290-ft. all aluminum arch highway bridge is currently under way at Arvida, Que., in which it is calculated to save 200 tons in weight over a comparable steel design.

In application of aluminum to *suspension bridges*, various considerations are involved and require careful analysis. In a suspension bridge with stiffening truss (or girder), any loss of stiffness by reducing dead weight is automatically compensated by increased truss stiffness when the design is made by the deflection theory. The reduction of stiffness from the lower value of E must be compensated by using a deeper stiffening truss.

Stiffness furnished by the stiffening truss, as against stiffness furnished by mere dead load, is highly desirable in increasing the structural damping against aerodynamic oscillations; and aluminum stiffening trusses may be built deeper than steel trusses without exceeding permissible stresses. For a given cable deflection and depth of truss, the stresses are reduced in proportion to the lower modulus.

In the Philadelphia-Camden Bridge, also in the George Washington Bridge, nickel steel truss chords had to be used to meet the high stress requirements imposed by the conditions of elastic deflections of the spans. The use of aluminum obviates this problem, permitting greater truss depths to be used with lower unit stresses.

The steel wire cables are the principal load-carrying element of a suspension bridge, and the most costly. Any reduction in the weight of the suspended structure yields a multiplied saving in the cables.

Even if the stiffening trusses or girders are built of steel, a material saving is possible in a long-span suspension bridge by building the roadway and floor system of structural aluminimum. The use of an aluminum open-grid floor will yield maximum economy. Careful analysis and checking of proper stiffness constants and of aerodynamic stability are pre-supposed.

AN ARTICLE TO MOLD THE FUTURE

Light-Gage Steel Offers New Building Opportunities

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THROUGH THE ECONOMY of modern production and manufacturing methods, use of light cold-formed steel panels for walls, floors and roofs of industrial buildings has become current practice. Some of these structures are literally a mile long and inclose scores of acres of floor space. Within its limitations, such construction, with steel 3/16 in. or less in thickness will exert increasing influence on the design of future buildings of other types than industrial.

For example, while the skyscrapers of the future probably will follow the general structural pattern of the past, some innovations will result from the use of light-gage steel. Probably the most outstanding will be the application of shallow, lightweight panels to secondary floor construction and exterior walls, reducing substantially the weight to be supported by the framing and the foundations—important items cost-wise.

As another example, the future two-storied house or commercial building may have walls framed with light-gage studs, the entire side of the structure being assembled in jigs and put in place in one operation. Or the walls may consist of steel panels, each several feet wide and one or two stories high. The floor framing may be light steel joists spaced about 2 ft. c. to c., or cellular steel panels. The roof, probably supported on light steel trusses, may have a ribbed steel deck. It may be composed of large panels or of a single prefabricated assembly. The exterior may be of traditional materials, enameled steel, stainless steel, or a combination of all three. And interior ceilings and sidewalls may be conventionally finished with metal lath and plaster, or may be of steel with any desired finish.

Such construction will reduce erection time and may make obsolete the erection of small dwellings or other small buildings with bricks, boards, blocks, mortar, nails—small units laboriously fitted by hand. Recent trends already point to large-unit fabrication.

STAINLESS STEEL WALLS inclose a 400-ft. long, four-story office building recently completed for the General Electric Co. at Schenectady, N. Y. (Wide World photo)

Development of light steel constructions is being aided by the progress made in welding and in finding ingenious ways of fastening panels together and attaching collateral materials to them. Commercial development of insulating materials also has broadened their scope of application. Now, new impetus has been given to the use of light steel by the introduction of rational design methods.

Design formulas available

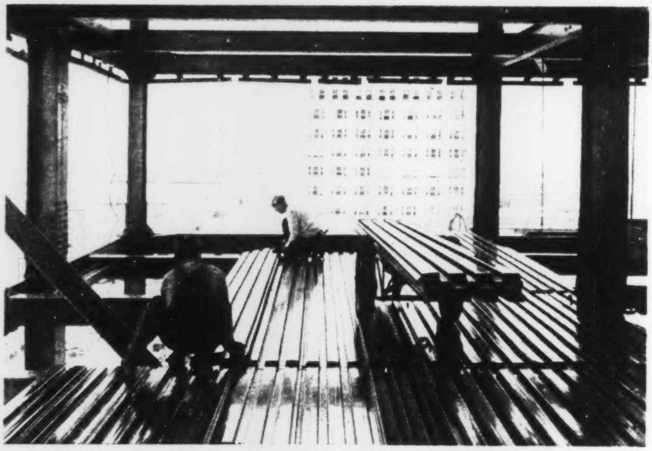
Until recently, the structural engineer had to depend largely on rule-of-thumb methods in designing structural sections formed of light-gage steel. While generally safe, these methods did not take full advantage of the potential economies or structural effectiveness of the metal.

Recognizing the need for proper design specifications for members formed of flat-rolled sheet and strip steel, the American Iron and Steel Institute in 1939 inaugurated a research program at Cornell University, to develop factual data from which such standards could be formulated.

Two principal results of this research, which has involved testing of nearly a thousand specimens of widely varying types, were the publication in 1946 of a "Specification for the Design of Light-Gage Steel Structural Members" and in 1949 of a supplementary "Light-Gage Steel Design Manual." Both were prepared by technical subcommittees of the Committee on Building Codes of the AISI.

The design specification, now nationally recognized as standard, establishes procedures for determining safe load-carrying capacities and deflections of beams, panels and columns made up of both stiffened and unstiffened elements. It deals with design problems peculiar to sections composed of plane, wide, thin elements, such as the prevention of instability and buckling under compression. And presenting formulas previously lacking, it provides a method for evaluating the lateral bracing effect of wall sheathing on studs and columns and for determining the proper spacing of attachments.

While the basic design principles applicable to light steel members are no different from those applicable to the conventional, heavier hot-rolled shapes, certain supplementary considerations enter the design of the light sections, particularly when they include wide, thin, compression elements. Here attention must be given to the prevention of local buckling. It becomes necessary to differentiate between elements stiffened along only one longitudinal edge (designated as unstiffened elements) and those stiffened along both longitudinal edges (designated as stiffened elements).



A LIGHT STEEL PANEL, easily handled by two men, provides about 30 sq. ft. of floor area. The cells are used as ducts. (H. H. Robertson Co. photo)

STEEL TRUSSES used on a Pennsylvania State College housing project weighed only 90 lb. Framing also was of light-gage steel. (Celotex Corp. photo)

Local buckling develops in unstiffened compression elements at predictable unit stresses—often below the yield point of the metal—calculated according to the structural properties of the full cross section of the member. Therefore, in the design of unstiffened compression elements, the properties of the full cross section are utilized, following conventional design practice, but to avoid failure by local buckling, a reduction is made in the unit working stress below that usually allowed for the metal. The amount of stress reduction necessary is related to the width-to-thickness ratio of the compression element.

Stiffened compression elements behave quite differently under load. Instead of buckling occurring suddenly at a critical stress, buckling waves develop gradually. That action causes redistribution of stress intensity as the load is increased, gradually reducing the effective width of the section. The higher the ratio of width to thickness of the element, the lower the unit stress at which the action starts.

This redistribution of compression stress, as load is increased, does not cause failure in a stiffened element until the unit stress in that element, near the stiffened edges, approaches the yield point of the steel. Therefore, the load-carrying capacity of stiffened compression elements may be based upon the full allowable unit design stress, calculated according to a reduced effective design width. The reduction of width increases as the width-to-thickness ratio of the compression element and the intensity of the compression stress increase.

Of necessity, some of the formulas used for light-steel design are complex. For that reason the new supplementary design manual was published.

Tabulations are included for about 230 sections formed of strip or sheet steel, including zees, single and double (back-to-back) channels and angles, with either stiffened or unstiffened flanges and legs. Charts, tables, graphs and examples are given. In general, this manual should prove useful to the designer in the same manner as the standard manual, "Steel Construction," published by the American Institute of Steel Construction, for heavy hot-rolled structural shapes.

Fire test results

Many American Society for Testing Materials fire tests have been conducted on light-gage steel floor, roof and wall assemblies to establish standard fire-resistance ratings. In fact, more test data are available on the fire resistance of these newer forms of light steel construction than on some of the older, conventional types.

Ratings range from one to four hours, depending on the protective medium employed. It is economically feasible to develop ratings up to four hours and higher where vermiculite-gypsum plaster on metal or wire lath is applied on the exposed side of the assembly.

In the usual residential, business, institutional or school occupancy, the average severity of the fire hazard is one-half to one hour of the standard fire-test exposure. In comparison, assemblies of formed steel develop fire-resistance ratings of about two hours where ordinary $\frac{3}{4}$-in. sanded-gypsum plaster on metal or wire lath is used as the protective medium.

Durability investigated

About 10 years ago, the AISI engaged the Pittsburgh Testing Laboratory to investigate the durability of light-gage steel, particularly with respect to the effectiveness of the shop coat of paint the construction had received. The report of this research, "Durability of Lightweight Types of Steel Construction," was published in 1942. The University of Michigan later, in a series of three bulletins, reported findings of a similar investigation. Both projects indicated that installations generally were in excellent condition, structurally sound and effectively protected.

Tentative standards of quality and strength for light-gage steel used to form structural members have been established by the American Society for Testing Materials, as follows:

ASTM A245-T—Steel from 2 to 18 U.S. std. ga. (0.2499 to 0.0278 in.)

ASTM A246-T—Steel from 18 to 25 ga. (00.0477 to 0.0225 in.)

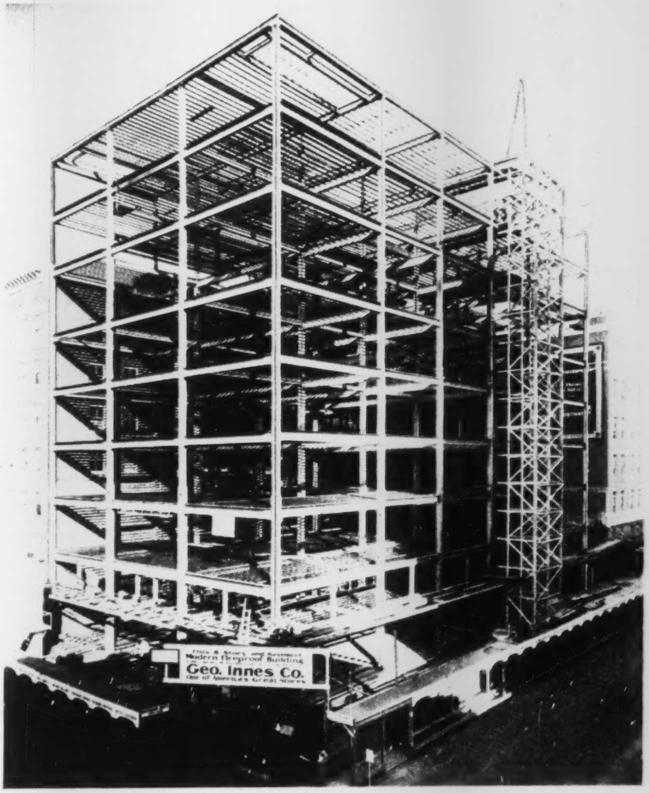
ASTM A303-T—Hot-rolled steel strip of structural quality (0.0255 to 0.2299 in. thick).

Advantages

To delineate the fields of application of light-gage floor members, it might be pointed out that economy dictates the use of the heavy conventional steel shapes where the loads to be supported require the full structural properties the heavy members provide. But in many ordinary occupancies (residential, business, school, institutional), the live loads are moderate, and relatively close spacing of the structural members is required to meet architectural considerations or the needs of the collateral materials that have to be attached to the structural members. Hence, open-web steel joists and cold-formed light steel systems have been developed to make more effective use of the metal.

Light-gage steel and open-web steel joist floor constructions are practicable and economical for use on ordinary spans for live loads up to about 125 psf., and in some cases, for somewhat heavier loads. Where these constructions are used, the dead load due to the floor system is lower than with conventional framing. The greater the number of stories in a building, the greater the importance of reducing the dead weight of the floor system and the greater the advantages of these lightweight steel constructions. Hence, they have been used in such recent buildings as the 30-story Mercantile Bank Building in Dallas and the 28-story John Hancock Building in Boston.

About two years ago, The National Standards Co. in Houston, Texas, found it necessary to put an addition on its existing 8-story reinforced concrete building. This structure had originally been designed for 16 stories of reinforced concrete, so that an 8-story addition would have been feasible. However, the company needed much more than 8 stories.



OPEN-WEB STEEL JOISTS support the concrete floors of an 8-story department store in Wichita, Kan. (Bethlehem Steel Co. photo)

The problem was solved with light steel floor construction, steel framing, lightweight concrete fill and fire-resistive plaster protection. In this manner, it was possible to add 14 additional floors.

Efforts are being made to modernize building codes to permit the use of light-gage insulated wall panels in multistory structures. Such panels have been used in hundreds of industrial buildings and small dwellings. They are light in weight, weathertight and afford the necessary degree of insulation and fire protection. Also, they consume less floor space than conventional masonry walls and thus increase rental income.

Either floor or wall panels can be erected quickly. A couple of men lift and place a floor panel as quickly as they could a 3 x 8-in. wood joist, but 30 sq. ft. or more of floor area results from the effort. A deck becomes immediately available — free from the shores traditionally required to support formwork—affording clear working space for the other trades and eliminating the fire hazard.

The cellular type of floor and side-wall panels provide space for plumbing, air conditioning, and electric lighting and telephone wiring. Utilized for radiant heating, these panels afford a degree of flexibility of heat control not obtainable where pipes are embedded in concrete slabs and large masses of concrete have to be heated or cooled before a desired change of temperature can be effected.

These advantages, plus the establishment of design standards and fire ratings, are reflected in the expanded use of light-gage steel in postwar buildings, and the trend toward this modern form of steel may be expected to continue.

AN ARTICLE TO MOLD THE FUTURE

THE FIRTH OF FORTH BRIDGE in Scotland, built in 1890, was designed for a wind load more than twice as great as present codes require. Safer—and more expensive—than necessary, it has its counterparts in many modern works. So . . .

Let's Stop Overdesigning Structures

Alfred M. Freudenthal
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IN THEIR UNCEASING SEARCH for more refined procedures of structural analysis, engineers find their efforts nullified by the crudeness of their approach to the specification of permissible stresses and associated safety factors. This situation can be rectified through the establishment of objective criteria of safety.

The concept of safety is probably the most important—and certainly the most controversial and vaguely defined concept in structural design. Safety factors varying between 1.25 and 10 are found in current design specifications for different materials and structural parts. These values were chosen arbitrarily on the basis of subjective judgment.

This method of selection does not permit incorporation in the everyday procedures of structural design of results of research on the properties of modern structural materials. Hence, the most refined analysis is deprived of its merits.

Structural design consists of two operations: 1. Determination of the effect of loads and service conditions; 2. Comparison of the load effect with a characteristic of the structure, termed resistance.

Load effect vs. resistance

The load effect is expressed directly in terms of the loads, unit stresses or deformations, the last being computed on the assumption of a linear relation between loads, stresses and strains. The resistance is expressed in the same dimensions as the load effect.

For example, a computed stress is compared with either the observed fracture stress or the yield stress of a material. A computed elastic deformation is compared with a limiting deformation associated with an observed strain limit. Or the design load is directly compared with the carrying capacity of the structure, which is evaluated by suitably combining the relevant dimensions and material properties.

The load effect is derived from the specified load by the use of rigorous methods of logical inference (structural analysis). In the process, a number of abstractions are usually made, and these restrict the validity of the results and their correlation with reality. Thus, stresses computed by conventional methods—which assume a perfectly homogenous, isotropic material, infinitesimal strains, a one-dimensional state of stress and idealized boundary conditions—are only imperfectly related to the real stresses in the loaded structure.

A similar imperfection marks the relation between the assumed and real mechanisms responsible for the resistance of a structure. However, evaluation of resistance is based in addition on material and geometrical characteristics obtained by experiment and observation. Since exact duplication of test results is seldom possible, even for a single observer, the geometrical dimensions and the observed material properties cannot be more closely defined than in terms of frequency distributions that summarize the different results of repetitive tests and observations. These represent the closest approach to constancy that real physical characteristics may attain because of their imperfect reproducibility (Fig. 1).

It is ultimately of no consequence whether the variation in a property—which is expressed by the frequency distribution—is inherent in the property observed, or characteristic of the procedure of observation, or the result of both. In the case of the observed tensile strength of a number of assumedly similar metal specimens, for instance, the recorded frequency distribution of the test results expresses the effect of the combination of all individual influences that may be responsible for the variation in observed strength. These would include differences in the quality of the metal, imperfections in the preparation and testing of the specimens, and errors in observation and measurement during the actual testing procedure.

Design loads differ from real loads

The comparison of load effect and resistance is made still more difficult by the arbitrariness with which design loads are specified and by the vagueness of the relation between real loading and design loading. Only for certain types of structures, such as railroad bridges, crane girders or industrial structures serving specific purposes, does a comparatively clear and simple relation exist between the real loading conditions and the selected design loads.

In these particular structures, occurrence of the maximum service (design) load is considered a relatively frequent and therefore normal service condition. Of course, a certain variability of the real load must be expected; but because the maximum load occurs relatively often, this variation is not really significant. The design load is fairly well represented by the maximum service load.

In other types of structures, such as buildings for human occupancy, highway bridges, airplanes and most machines, the high variability of the real loading is of considerable significance in design. The maximum load, which is often several times larger than the normal service load, occurs only a few times during the entire period of service. To formulate a rational relation between the real loading and the design loading under such conditions, it is necessary to introduce statistical concepts. With the aid of these, the variability of the acting loads can be adequately expressed, and the probability of occurrence of various loading conditions estimated on a rational basis.

In view of: (1) the uncertainties in the evaluation of resistance; (2) abstractions, approximations, simplifications, and outright errors in the methods by which the load effect, service conditions and resistance are determined and which, in their entity, make up the component of ignorance contained in any theoretical analysis or description of real processes; and (3) the intrinsic variability of the load and other service conditions, it is evident that a comparison of the load effect with the resistance of a structure cannot be performed in terms of an equation. It must be expressed only in terms of a correlation range leading to an inequality. And this correlation range must provide for the uncertainty, ignorance and variability contained in the compared design characteristics.

Safety factor defined

If, due to the aforementioned causes, the load effect s may be subject to a maximum upward variation of a range Δs, while the resistance r may be subject to a maximum downward variation of a range $-\Delta r$, the prevention of failure requires that

$$(s + \Delta s) < (r - \Delta r) \qquad (1)$$

The condition of minimum safety is obtained by replacing the unequal sign by the sign of equality. Hence,

$$s = \frac{1 - \dfrac{\Delta r}{r}}{1 + \dfrac{\Delta s}{s}}\, r = \frac{1}{n} \cdot r \qquad (2)$$

where

$$n = \frac{1 + \dfrac{\Delta s}{s}}{1 - \dfrac{\Delta r}{r}} \qquad (3)$$

In Eq. 3, n represents the minimum value of the factor by which the load effect must be multiplied to be directly comparable to the resistance of the structure.

The definition of this factor is identical with the conventional definition of safety factor, which is thus identified as a factor of correlation between load effect and structural resistance, reflecting the variability, uncertainty and ignorance inherent in structural design. If the range of variation can be determined, or even estimated with a fair degree of accuracy, the required minimum value of the factor of safety can be computed from Eq. 3.

The safety factor varies

Each value of this factor is associated with a definite assumption regarding the selection of the design load and the evaluation of the resistance of the structure.

For example, assume that the design load represents the maximum possible service load. And assume also that the design resistance is determined under the most extreme, unfavorable assumptions concerning the resistance mechanism and the range of variation of geometrical dimensions and material properties. Then, the minimum safety factor will only slightly exceed unity. In this case, both Δs and Δr tend toward zero. They compensate only for the ignorance contained in the theoretical concepts and the analysis, the range of which can be made arbitrarily narrow by using the most accurate and reliable procedures of analysis that are available.

On the other hand, the lower the design load relative to the maximum service load, and the cruder the concepts and methods of the structural analysis, the larger the minimum factor of safety must be. It must be increased also if the range of variation of the material properties is estimated less conservatively or if this variation becomes larger because of lack of control in the process of manufacture and the method of selecting materials.

Because of the interdependence of the variables, a permissible stress, for example, has a real meaning only in conjunction with the specification of the design load, the required accuracy of the structural analysis and the level of control imposed on the manufacture and selection of the material. Changes in any of these must be immediately reflected in a changing allowable stress, and vice versa.

Evaluation of safety is difficult

The conventional procedure by which specifications for design loads are set up, is, therefore, inadequate, since they are prepared independently of the specifications for permissible stresses and quality control—generally with each type of specification being dealt with by a different professional group. It leads necessarily to a complete lack of correlation between these specifications and to a resulting lack of balance in the design based thereon. It is practically impossible to evaluate the real safety inherent in a design in which such a correlation does not exist or is not rational.

Another point that must be con

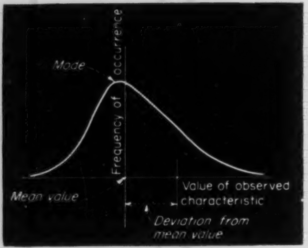


FIG. 1. A DISTRIBUTION CURVE indicates the frequency with which observed values occur.

sidered is that as a factor of correlation of the load effect with the resistance, the safety factor can only refer to the combination of all loads and service conditions that might exhaust the resistance of the structure. Thus, the frequent attempts to devise a concept of partial safety in terms of different safety factors for dead load, live load and other service conditions are meaningless. They do not reflect a rational concept of safety.

Such attempts are usually based on the assumption that the difference in the range of possible variation between the very nearly constant dead load and the highly variable live load can be compensated for only by different safety factors. This difference, however, is more adequately provided for by the combined safety factor which is obtained by statistical summation of the contributing variations.

Statistical summation infers that the resultant range of variation of a characteristic made up of a number of properties, each of which is subject to a certain range of variation, is much smaller than the algebraic sum of the constituent ranges of variation. This is based on the fact that the probability of a simultaneous variation of all constituent properties over a similar range and in the same direction is only a fraction of the probability of such a variation occurring in a single constituent property.

In mathematical terms this law of statistical superposition is expressed by the equation

$$\Delta = \sqrt{a_1^2\Delta_1^2 + a_2^2\Delta_2^2 + \ldots + a_n^2\Delta_n^2} \qquad (4)$$

in which Δ denotes the range of variation of the resulting characteristic

$$X = F(x_1, x_2, x_3 \ldots x_n) \qquad (5)$$

F is an arbitrary algebraic function of the constituent properties $x_1, x_2, x_3 \ldots x_n$, the ranges of variation of which are defined by $\Delta_1, \Delta_2, \Delta_3 \ldots \Delta_n$. The factors $a_1, a_2, a_3 \ldots a_n$ are obtained by partial differentiation of F with respect to the individual constituents, or

$$a_n = \frac{\delta F}{\delta x_n} \qquad (6)$$

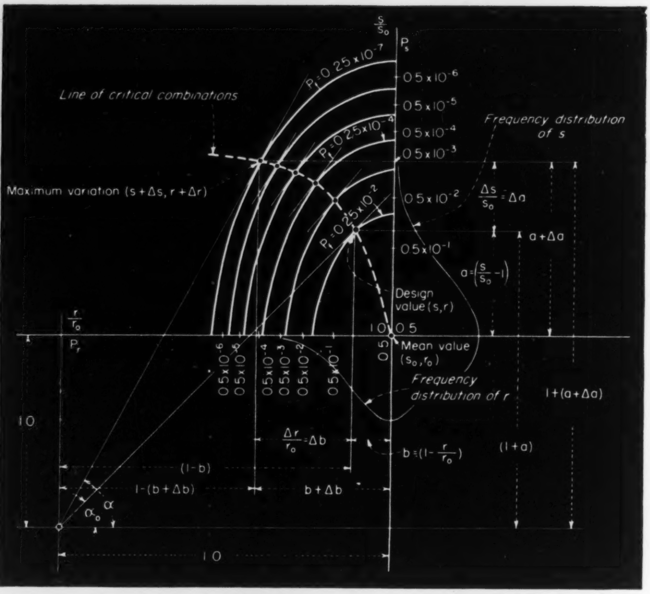

$\frac{s}{s_o}$
P_s
$P_t = 0.25 \times 10^{-7}$
$P_t = 0.25 \times 10^{-4}$
$P_t = 0.25 \times 10^{-2}$
0.5×10^{-6}
0.5×10^{-5}
0.5×10^{-4}
0.5×10^{-3}
0.5×10^{-2}
0.5×10^{-1}
Line of critical combinations
Maximum variation $(s+\Delta s, r+\Delta r)$
Frequency distribution of s
$\frac{\Delta s}{s_o} = \Delta a$
$a + \Delta a$
$a = \left(\frac{s}{s_o} - 1\right)$
Design value (s,r)
1.0
0.5
$\frac{r}{r_o}$
P_r
0.5
Mean value (s_o, r_o)
Frequency distribution of r
$1+(a+\Delta a)$
1.0
$\frac{\Delta r}{r_o} = \Delta b$
$b = \left(1 - \frac{r}{r_o}\right)$
$(1+a)$
$(1-b)$
$1-(b+\Delta b)$
$b+\Delta b$
α_o
α
1.0

FIG. 2. GRAPHICAL EVALUATION of critical combinations of design characteristics, on the assumption of a normal distribution of resistance and load effect, both of which are represented as relative frequency distributions.

Assume, for instance, that the load effect in a section of a continuous steel beam is expressed in terms of the sum of the dead-load and live-load moments

$$F(w_d, w_p) = C_d w_d L^2 + C_p w_p L^2$$

where w_d and w_p denote, respectively, a uniformly distributed dead and live load, and C_d and C_p the appropriate moment coefficients. Then the range of variation of the load effect is

$$\Delta = \sqrt{C_d^2 L^4 w_d^2 \left(\frac{\Delta_d}{w_d}\right)^2 + C_p^2 L^4 w_p^2 \left(\frac{\Delta_p}{w_p}\right)^2}$$

since $a_1 = \partial F/\partial w_d = C_d L^2$ and $a_2 = C_p L^2$.

Assume further that the dead load may exceed the design value by 20 percent, while the live load may attain double its design value. Then, the resulting variation of the load effect will not exceed

$$\Delta = C_d L^2 w_d \sqrt{(0.2)^2 + (C_p/C_d)^2 (1.0)^2 (w_p/w_d)^2}$$

depending, therefore, on the ratio of dead to live load. With coefficient $C_p = 1.5\ C_d$ and $w_p = w_d/3$, for example, the resulting range of variation does not exceed 53 percent of the dead load moment, or about 36 percent of the total moment. These values should be compared with the 20 percent variation in dead load alone and the nearly 50 percent increase in total moment obtained by summation.

Similarly, in determining the resulting range of variation Δ associated with a number of concentrated loads P, each of which is subject to a variation Δ_o, the application of Eq. 4 and 6 to $F = mP$, where m is the number of loads, leads to the relation $\Delta = \Delta_o\sqrt{m}$ and a resulting specific range of variation $(\Delta_o/P)(1/\sqrt{m})$. Thus, for instance, a variation of 100 percent in an individual force produces a resulting variation not exceeding 32 percent if 10 loads act simultaneously, as in the case of locomotive wheels exerting variable (impact) forces.

If it is assumed that the resistance of the section of the continuous beam may be subject to a maximum downward variation of 25 percent of its design value, as suggested by the scatter of the observed strength values of steel, the minimum safety factor for the design, according to Eq. 3, would be

$$n = \frac{1.36}{1 - 0.25} = 1.81.$$

The safety factor as expressed by Eq. 3 is derived on the basis that failure should be prevented, even if a very improbable upward variation of the load effect coincides with an equally improbable downward variation of the resistance. Since no range of variation can be defined as impossible—only as highly improbable—failure cannot be prevented with certainty, but only with a selected degree of probability.

Let P_s denote the probability of occurrence of the load effect, $s + \Delta s$, and P_r the probability of occurrence of the resistance, $r - \Delta r$. Then, the probability of coincidence of both extreme ranges of variation is, according to statistical principles, $P_f = P_r P_s$. This is the resulting probability of failure.

Both the load effect and the resistance (represented as relative frequency distributions) are plotted in Fig. 2 along the axes of a rectangular coordinate system. The origin coincides with the mean value (s_o, r_o) of the distributions. Under the assumption of a Normal (Gaussian) distribution of r and s, a family of curves, P_f = constant, has been drawn. The probability values of the points on these curves are the products of the relative frequencies, or probabilities, of their coordinates.

With the introduction of the expressions for a, b, Δa and Δb, indicated in Fig. 2, into Eq. 3, the safety factor becomes

$$n = \frac{1 + \frac{\Delta s}{s_o}\,\frac{s_o}{s}}{1 - \frac{\Delta r}{r_o}\,\frac{r_o}{r}}$$

$$= \frac{1 + \Delta a/(1 + a)}{1 - \Delta b/(1 - b)}$$

$$= \frac{1 - b}{1 + a} \cdot \frac{1 + (a + \Delta a)}{1 - (b + \Delta b)} \qquad (7)$$

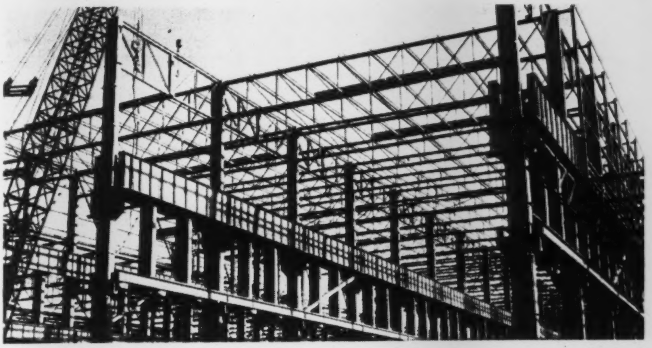
Vectors drawn from a point ($s/s_o = -1$, $r/r_o = 1$) to the points (s/s_o, r/r_o) and $\left(\frac{s + \Delta s}{s_o}, \frac{r - \Delta r}{r_o}\right)$ make angles with the axis of abscissae of α_o and α, respectively. In terms of these angles,

$$n = \cot \alpha_o \tan \alpha \qquad (8)$$

Since for every value of n the critical combination of design characteristics and of variations is that associated with the maximum probability of failure, these combinations are defined by the tangents drawn from the point (−1, 1) to the curves P_f = constant. Hence, combinations of load effect and resistance should be selected only along the "line of critical combinations" through the tangential points.

Non-linear load-stress relations

As long as the relation between load and stress remains linear up to the point of failure, s and r can be expressed in terms of unit stresses. Under such conditions, r/n represents the allowable unit stress. However, if the load-stress relation changes with increasing load or decreasing resistance, as under conditions of elastic-plastic deformation, or of finite deformations (buckling), s and r can be expressed only in terms of loads, forces or moments.



FOR CRANE GIRDERS and industrial structures serving a specific purpose, the load effect may be evaluated fairly accurately, since the design load is closely represented by the maximum service load. For most other structures service loads are not so definite.

Under such conditions, the values $s + \Delta s$ and $r - \Delta r$ must refer to the same state of the structure. This state, however, will generally be different from the state associated with the design values s and r. Thus, in the evaluation of the resistance, $r - \Delta r$, of a mild-steel structure under static loads, for instance, the plastic redistribution of stresses must be taken into account if the maximum load effect, $s + \Delta s$, is sufficiently high to transform the structure, which is elastic under the design load and resistance, into an elastic-plastic state.

The concept of safety, as expressed by the safety factor in Eq. 3, implies that the load effect and the resistance of the structure are independent of each other and of time. This is true only when the effects of fatigue or creep, or both, need not be considered.

Under conditions of fatigue, the resistance of the structure decreases with every cycle of a load that causes the resistance associated with the endurance limit to be exceeded. When creep is involved, the resistance decreases with time and depends on the load variation. With both fatigue and creep, as in high-temperature service design of metal parts, resistance not only decreases with the number of cycles and with time but also depends on the loading sequence.

Thus, the safety factor becomes a function of the loading history and of time. Under such conditions, its rational evaluation is extremely difficult, since analysis is required of the sequence of inelastic states through which the structure passes as a result of the loading sequence.

An understanding of the real nature of the safety factor is of immediate practical importance. The knowledge is essential to the preparation of rational design specifications, which determine the effectiveness with which materials can be utilized and encourage the development of better materials.

Studies under way

Increasing concern is being shown by professional organizations over the necessity of solving such basic problems. Recently, for example, the American Society of Civil Engineers set up a committee to study the problem of safety. Since the amount of available data is surprisingly small, one of the first steps in this work must be collection, coordination and evaluation of data concerning the variability of the real loading conditions for different types of structures. Fluctuation in the values of the observed mechanical properties of structural materials must be treated similarly. And at the same time, a thorough study must be undertaken of the significance of the material properties observed in standard mechanical tests with regard to the performance of materials in actual structures.

Very little has been done in this direction. Most engineers accept at face value the conventional classifications of structural materials in terms that, in most cases, are completely unrelated to real structural performance. There is little exaggeration in the statement that nothing has succeeded in confusing the engineer more than the testing machine.

In the coming years, increasing emphasis undoubtedly will be placed on the development of effective procedures of structural design and evaluating and selecting engineering materials. This will require the use of more rational concepts of structural safety and of the performance and resistance of materials and structures.

AN ARTICLE TO MOLD THE FUTURE

Engineered Earthmoving For the Job of the Future

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Designing the performance and costs of machinery just as you would design a bridge or a building is a far cry from the "old days"—but it can be done. Such designing moreover must assume a continually greater position of importance if the big construction jobs of the future are to be handled efficiently and successfully.

A few basic principles covering inherent operational characteristics make it possible to evaluate types of machinery, one against the other, or to plan a pe.formance and cost program around a set of conditions, with machinery already in possession. Such work—amounting to a design problem—offers almost certain possibilities of increasing output and lowering costs. An attempt will be made presently to show this possibility. The main facts cited are taken from an actual problem faced by an excavating firm that particularly wanted a desirable-looking contract.

But first, a few principles will be stated. The well-planned, or designed, machinery application should: (1) reduce investments to a minimum; (2) produce the greatest unit performance; and or (3) reduce unit costs below similar or competitive methods or machinery; and (4) indicate a good economic position during a potential life.

A list of factors affecting performances and costs seems formidable, for with small variations in item values, the number of different answers, which could be obtained, would run into the ten thousands. In practice, however, the number is greatly reduced and rules-of-thumb figures are sufficient to assure suitable accurate answers. For instance "rolling resistance", which is nothing more than an arithmetical evaluation of underfoot conditions in terms of work, could be set forth in increments of one pound, or even fractions of a pound, and thus indicate the use of several hundred values in that one item alone. In practical use, however, it is sufficient to establish a half dozen. Intelligent use of this small group will create a surprising range of economic considerations from the amounts of original investments to final unit costs.

Basic "design" factors

In earth or materials movement, the factors most potent in calculations of performance and costs are:

1) Machine weight, empty and gross, or fully loaded.
2) Material weights, and their attending characteristics of swell, shrinkage and percentage of voids.
3) Horsepower; evaluated in terms of accomplishment, and its rating whether flywheel, drawbar or bare.
4) Grades, adverse or favorable.
5) Rolling resistance; often a combination of tire characteristics and surfaces.
6) Coefficient of traction: slippage or its tendency.
7) Speeds and different speed options, whether feasible or not.
8) Acceleration and deceleration, and the time they consume.
9) Tires; choice of suitable sizes and air pressures to decrease work, increase performance.
10) Gear ratios; options to meet work demands to increase performance.
11) Altitudes, and the loss of power that is involved.
12) Mechanical factors: fuel, grease, repairs, labor.
13) Efficiencies, mechanical or human, the latter including the all-powerful "performance design" factor of management and supervision.

A practical example

A practical example of the use of some of these factors can be set up in which a good job will be assumed, with a 4-mile one-way haul over zero grades. The material weight in place will be assumed at 2600 lb. per cu. yd. with a 30 percent swell. It can be further assumed that a contractor particularly wants the job and has 125 brake-horsepower, rubber-tired tractors, with 14-yd. heaped-capacity wagons. He realizes similar machinery will be bid competitively. Outside of paring possible profits to the quick, what can he do to give himself a bidding edge?

He begins his analysis in somewhat the following manner:

Material weighing 2600 lb. per cu. yd. in place with a 30 percent factor will weigh 2000 lb. loose. A 14-yd. heap at this weight would give a

EFFECT OF ROLLING RESISTANCE ON PERFORMANCE AND COSTS

Rolling-resistance in pounds per ton	40#	65#	100#	150#
Number of machines to maintain a production of 350 cu.yd. per hr.	8	10	13	18
Haul speed, maximum, m.p.h.	25	15	11	7
Return speed, maximum m.p.h.	25	25	25	17
Investment in hauling equipment	$140,000	$175,000	$227,500	$315,000
Hauling cost per cu.yd. at $8.80 per hour for each machine	20.1¢	25.1¢	32.7¢	45.3¢

maximum net load of 28,000 lb. A calculation of weight distribution and tire capacities shows that the tires would carry a gross (loaded) weight of 75,000 lb. With an empty weight of 30,000 lb., a net load could weigh 45,000 lb. and be within recommended tire capacities. 45,000 loose lb. of this dirt requires a heaped wagon capacity of 22½ cu. yd. A heaped capacity of 22½ cu. yd. could be arranged for the flaretop type of wagons involved.

A maximum speed of 19 m.p.h. was standard in the wagons, but would the horsepower handle 75,000 lb. at that speed? The amount of work (rimpull) available at 19 miles top speed is 2100 lb. With 37½ tons of gross load it is shown (2100 ÷ 37½) that it would be possible to travel 19 miles an hour with a 56 lb. per ton rolling resistance (56 lb. of rimpull work per ton of gross vehicle weight.) Further study reveals that if the rolling resistance were reduced to 40 lbs. (which value results from a smooth road with well maintained and watered surface) only 1500 lb. of rimpull would be required instead of 2100 lb., and a greater speed would become possible.

A further calculation shows it possible to obtain 1500 lb. of rimpull at a speed of 27 m.p.h. An optional gear allowing a top speed of 25 m.p.h. is available—thus allowing a small amount of excess power to assure acceleration. A simple and inexpensive exchange of gears thus makes it possible to increase haul speeds from 19 to 25 m.p.h., and reduce the round trip time by more than 6 min.

A four yard shovel is assumed to excavate about 350 cu. yd. per hr. Eight of the wagons are calculated to fit that production and maintain it.

If the original machine in its standard form is figured, 16 wagons would be necessary to maintain the production, and hauling costs would double. With the standard machines changed over to fit job conditions, including the gear changes and top extensions, representing an extra expenditure of about $700 each, the investment, per unit, would be about $17,500. Thus, an investment of $140,000 (8 x $17,500) becomes capable of doing the work normally requiring an investment of $268,800 (16 x $16,800).

Further, assuming an hourly ownership and operating expense for each original machine at $8.00 an hour, the hauling cost with 16 machines would be 36.6 c. per yard. With 8 machines doing the same work, adding a 10 percent hourly increase in costs due to the same machine working somewhat harder, the hauling cost per yard would be 20.1c.

Some factors must be created

Obtaining this result will obviously depend upon the contractor adhering to the plan and creating some of the factors around which the calculations hinge—the good road-bed for one. Also the assumptions need to be approximately correct. Suppose, for example, the material weight turned out to be 3000 lb. per cu. yd. in place. A net maximum of 45,000 lb. would result in 15-yd. bank measurement loads instead of 17.3 cu. yd. and 9 wagons would be necessary at a hauling cost of 22.6 c. per yard instead of 20.1 cents. The investment would have to be $157,500 instead of $140,000 to do the same work.

A similar effect on investment and costs would be found if the swell factor was too low, and the corrections created smaller loads.

The low results found by calculation are based upon the creation of 40 lb. per ton rolling resistance. If greater rolling resistance is allowed to develop because of the rutting, or softening, of the road surface, or by the maintenance of improper tire pressures, or in the negligence of the original construction, performance will drop off materially and result in: Lowered shovel performance, or the need for more hauling units to do the prescribed amount of work. In either case costs go up. An accompanying table shows how investments, performances and costs vary with changes in rolling resistance.

Evaluating the design factors

Each of the design factors has its own peculiar effect on the final result, and each therefore needs to be thoroughly understood.

Weights. An accurate knowledge of weights involved in a problem affect: (a) speeds of travel; (b) acceleration; (c) quantities delivered; all of which influence (d) costs.

When very light weights are to be encountered, a given amount of horsepower can do more work either in greater loads or in higher speeds, or both. This is a good place to start analyzing the potentials of a machine's performance.

Materials. Unit weights of materials, either in solid or loosened form, go to make up gross loads. Swell and compaction characteristics also point to the weights that will develop as well as the size of the carrier necessary to accommodate them. Obviously material that bulks excessively will produce less "pay dirt" in a carrier than one which does not. The consequences of this situation were presented in the previous example.

Horsepower. In excavation hauling equipment, there are, unfortunately, several means of stating horsepower ratings with a great difference in their effect on performance calculations. With track-type machines, horsepower is generally stated in terms of drawbar pounds. It is the amount of work the tractor is capable of doing at sea level, in pulling or pushing, over zero grades, after its own locomotion is accounted for. Over adverse grades the weight of the tractor absorbs a portion of its own power and the balance is available for other work.

In explanation of work power a tractor rated with 130 drawbar horsepower is capable of 130 × 33,000 = 4,290,000 ft. lb. per min. of work. If the low gears are arranged to give a speed of 1.7 m.p.h. or 149.6 ft. per min., the drawbar pull for all towing or pushing work would amount to 4,290,000 ÷ 149.6 = 28,676 lb. In this manner, all other figures involving combinations of speeds and drawbar pounds pull are calculated; the whole based upon a horsepower rating at the drawbar which is created at the rate of 33,000 ft. lb. of work per minute per horsepower.

In automotive work, there is a great deal of conflict and confusion in the ratings, some of which are misleading. One manufacturer rates horsepower at the flywheel. Others rate it bare, and the fan and other power-consuming attachments must be added later to reduce the workpower and cause a confusion in the minds of buyers who are attempting to judge relative performances on a horsepower basis. Some, further, rate their engines at continuous output while others rate the engines on an intermittent basis. For the moment, there is no common ground of rating, so inquiries must be made in order to obtain correct figures from which performance calculations can be accurately put together.

In the case of automotive tractor ratings the differences can be evaluated about as follows—rated according to their ability to do work:

1) Rimpull horsepower. This particular term is seldom applied to rubber-tired tractors. Rather, the horsepower is stated in some vague manner as amounting to some figure and rimpull pounds, or tractive effort may be stated (or not) in working pounds, at listed speeds.

2) Brake or flywheel horsepower. This rating generally includes accessories such as pumps, cleaners, fan, etc., all of which absorb horsepower.

3) Bare engine, free of accessories (the fan representing the greatest horsepower robber) at a rating representing *continuous* use. This rating is generally one indicated for automotive use, there being another for stationary use which assumes an engine running the clock around for long periods. From this rating there is another loss to an *intermittent* rating representing the maximum for momentary classification.

4) Bare engine free of accessories at an intermittent rating. Often the rate at which engines are advertised for automotive use.

If a 200 brake or flywheel horsepower engine were compared to others rated at 200 horsepower, each of which followed the succession shown above, their work power for hauling calculations would end up about like this:

Rimpull horsepower—
200 Hp or 100% at the tires.
Brake horsepower—
176 Hp or 88% at the tires.
Bare, Continuous—
158 Hp or 79% at the tires.
Bare, Intermittent—
130 Hp. or 65% at the tires.

These figures should indicate the necessity of obtaining correct and well-understood ratings in order to evaluate machinery possibilities, or for the matter of establishing performance improvements.

Grades. Adverse grades use up approximately 20 lb. of engine rimpull or drawbar per gross ton of weight of the machine per one percent of slope. Favorable grades add to the performance of a machine at the same rate.

Instances are easily possible in which a small adverse upgrade, over which a certain rate of performance with a given number of machines can be established, can be changed to a small favorable down grade to materially reduce investments and ultimate unit costs.

As an example: a rolling resistance of 100 lb. per ton plus a grade resistance of 2 percent, or 40 lb. per ton, could easily cut the hauling speed of a machine in half. A favorable grade of 2 percent over the same rolling resistance would reduce the total resistance, thus, from 140 lb. per ton to a total of 60 lb. per ton and double the haul speed, but not affect the use of the same top speed for return hauls.

Rolling resistance. The effect of rolling resistance has been already indicated in a series of several recommended values. It is given altogether too little consideration in the calculations of machinery performance, because too little is known about it. Actually rolling resistance is not a condition of the ground surface alone. It is a combination of tire sizes and pressures *and* surface conditions.

In further explanation, the effects of a soft or spongy ground condition normally setting up a high rolling resistance (100 to 150 lb. per ton) can be modified greatly by using larger tires with air pressures as near the bearing value of the ground as possible. As tire penetration is reduced by the use of large low-pressure tires, rolling resistance is reduced, and if penetration can be eliminated entirely a minimum rolling resistance is established at a rate of 30 to 40 lb. per ton depending upon machinery design and care of manufacture.

When tires are capable of establishing such results their value in extra performance and in the lowering of costs is one of the cheapest money earners in the construction-excavation field. Inversely, if a rolling resistance tends to be a little low, the improper use of tires and pressures can raise the resistance to a costly point.

Further, where over-capacity tires are suitably fitted to a hauling machine, the efficiency of the carrier can even be increased on perfect roadways by increasing air pressures to maximum ratings, thus gaining the easier draft of the greater diameter rubber as well as the longer life of the under-loaded tire.

Too much cannot be said for tires in their effect on hauling equipment performance. Dollar for dollar, a suitable over-size tire expenditure is the cheapest method of gaining lower hauling costs.

Coefficients of friction. Track grousers and rubber each have definite traction, or coefficient of friction characteristics on different surfaces. In order to enhance the performance of either type of machine where slippage occurs (unless serious adverse grades are present to reduce performance) the addition of calculable weights to the driving areas on the ground will be the answer.

In good earth footing grouser tracks can be expected to deliver about 90 percent of their weight, provided sufficient horsepower is available. Rubber tires about 55 percent. For instance, dry sand has a traction value amounting to about 30 percent of the weight on the driving areas, tracks or tires, so that the work power of a 40,000-lb. tractor is about 12,000 lb. before slippage and loss of work power result. In order to utilize the potential of the horsepower, imposed weights should be added, and for each 1000 lb. an added 300 lb. of work power could be expected (up to the limits of the horsepower to deliver the work).

An appraisal of traction values for the type of machine considered and the surface over which work must be done will indicate the type of machine to use, or the work possibilities of the individual machine.

Speeds and speed options. The possibility of certain speeds is a calculation based upon gross and empty weights, horsepower, grades and rolling resistance.

Acceleration and deceleration. These are items of time consumption which may best be considered as common to every haul of any length. They are as much a fixed item as loading or dumping or spotting or turning or any other. Starting points should be arranged to reduce their effect on the over-all time of a haul. Start down hill for example.

Excessive weight, limited horsepower, high rolling resistances and starting on adverse grades all lengthen their effect on time cycles. For example, a heavy load accelerates and brakes slower than a light one. A high rolling resistance retards acceleration greatly even while helping braking. Lack of horsepower increases starting time. Starting up grades slows the acceleration quite noticeably. Be sure to note the areas in which these parts of the haul occur and plan machinery movement to take advantage of the conditions that can be created. This will show surprising results in reducing costs and even in initial investments.

Tires. A very potent possibility in designing performance. Their favorable use has been discussed to some extent under the heading "Rolling Resistance".

Gear ratios. Most hauling machinery has optional gear ratio groups that may be bought in the original package, but which are also available for reasonably inexpensive changeover in existing machines.

Analysis of the conditions under which machines are to be used—similar to the hypothetical job discussed in the first part of this article—often makes it possible to "up" the performance and reduce costs to a point where competitive bidding is not a price-cutting process but a means of under-bidding similar machinery even while profiting more in its use. Often an optional higher gear makes it possible not only to haul over zero grades at much higher speeds, but to traverse adverse grades at a higher speed because the changed gear arrangement allows it.

Altitudes. With the knowledge that horsepower (and therefore work output) suffers with the gain of altitude—above a thousand feet—it is well to recognize the fact and figure performances accordingly. A rule of thumb for 4-cycle diesel engines lies in a loss of approximately 3 percent per 1000 ft. of elevation above 1000 ft. Thus, if a tractor delivered 30,000 lb. of drawbar at sea level, at 8000 ft. the loss of power would amount to about 21 percent, and the drawbar would be reduced to 23,700 lb. A loss of performance would develop that would seriously affect costs. A solution would be more horsepower or the development of original costs which would make suitable allowance for losses.

Chart may be used

Visual means of depicting the results of analysis and performance designs are a valuable adjunct to the work. The accompanying chart, showing the results of a study in the economics of hauling, is one of these.

It seems probable that if a group of excavation and hauling contractors were asked the question "How much will the cost of hauling alone vary in the handling of different maintained rates per hour of excavation?" the answer would probably be, "About the same." They would point out the hourly cost of a truck or wagon is fixed in any case and, if the haul distance is the same and the truck capacity and speeds remain the same, the cost per yard for hauling would be about the same. The chart shows otherwise. It is based on an ownership and operating cost per hour per tractor-wagon of $8.00; a maximum hauling speed of 18.9 mph. an efficiency of 75 percent (45-min. hour); and a wagon capacity of 15 yd. struck.

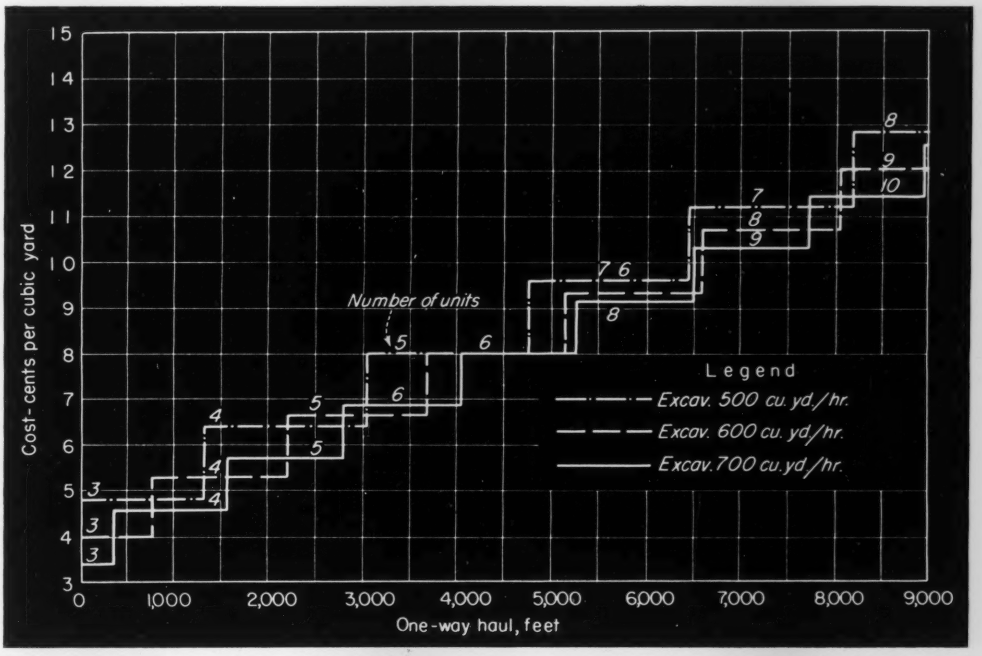
The number of units necessary to maintain each rate of production is set up in the curve itself. The one-way haul distance in feet is used for the abscissa, and the cost in cents per cu. yd. for the ordinate.

As the values of each curve unfold themselves, each vertical rise is occasioned by adding the cost of another $8 an hour unit (as needed to maintain the production rate), to the whole hauling cost. Into this amount the rate of production per hour is divided to obtain the cost per yard. The length of the horizontal portion of each curve is a reflection of the time actually spent in travel rather than under the shovel or loader.

The difference in the horizontal and vertical lines of each curve, one with the other, is caused by the difference in the rate of production and the time spent in travel and the numbers of units required.

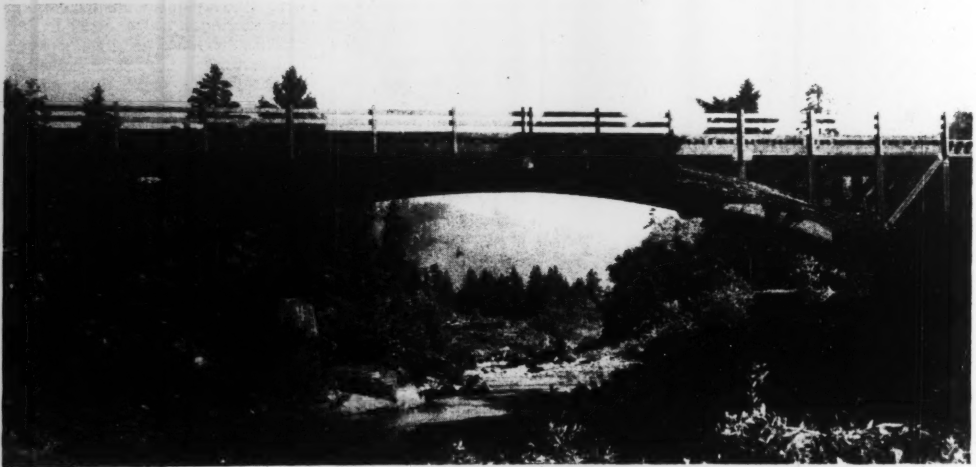
Where, and how else, could a set of figures so clearly indicate the relative merits of production rates? The varying periods of greatest or greater economy and greatest or greater expense will show where and how to fit machinery to any certain haul distance to obtain the best results.

In conclusion, it can be said for many large and successful contractors that they are approaching these design methods; whereas the smaller operators, perhaps because of limited resources, are largely unaware of them. Much can be added, though, to the knowledge of the equipment-estimating engineer, however experienced his company's and his own past—and the future will include these methods more and more.



HAULING COSTS ANALYZED GRAPHICALLY—Fifteen-yard tractor-wagon units in this example cost $8.00 an hour, operate at 18.9 mph. maximum speed and work 45 min. every hour. Number of units to maintain each rate of production is stated on the curve.

AN ARTICLE TO MOLD THE FUTURE



GLUED-LAMINATED TIMBER ARCHES, creosote treated, support a combination railroad and highway bridge in Oregon.

Big Timbers from Small Sticks

Structural timbers are now being "grown" in the shop in much larger sizes and of higher strength than Nature has produced.

By gluing together thin lumber laminations, fabricators have produced members for dredge spuds, curved and straight truss chords, two and three-hinged arches, tied-arch ribs, girders, columns and dome rings. Even without precise technical information for full economy, a whole new structural timber industry has been developed. Single timbers have been produced up to 36 in. square and up to 115 ft. long. Glued laminated timber bowstring trusses have been built up to 232 ft. long, and glued laminated timber arches up to 200 ft. long.

Considerable research has been carried out recently to assure more effective use of these glued laminated members, and a design specification is being formulated. In the meantime, considerable helpful data can be presented to enable engineers to design with reasonable efficiency in this medium, and various firms that have specialized in glued-laminate design and manufacture can contribute from experience.

Verne Ketchum

Chief Engineer, Timber Structures, Inc.

Portland, Ore.

Once, trees were plentiful and we could afford to be extravagant with our timbers. Now, however, forests have dwindled, logging operations have moved farther back in the woods, and expanding population and destructive wars have increased the consumption of wood. New technical skills and machine production are needed to balance supply and demand and help hold in check the flood-level costs of timber construction.

To meet the challenge, timber construction in the past decade has expanded greatly in the fields of prefabrication, preservative and fire-retardant treatments, connectors and glued laminated construction. Structural timbers are now detailed and shop fabricated like steel, and shipped to the job for assembly and erection.

Greatest development in the lumber industry has been in the field of glued laminated construction. Now we may build without those limitations of size, length and checks and splits that have handicapped the use of wood for long spans, heavy loads and fine appearance.

Glued laminated (glulam) timbers may be defined as combinations of wood and glue in which the grain of all laminations is approximately parallel. Laminated timbers are those in which laminations are secured together by mechanical fastenings. Sawn timbers are solid pieces that are neither laminated nor glued laminated.

"Glulam" timbers have many advantages and, except perhaps for cost, no disadvantages. Size and shape are limited only by handling and transportation facilities. The timbers can be shaped and fashioned for tapered sections, and may be curved without band sawing, steaming or pickling operations, which waste material and weaken wood fiber. Being "shop grown" they are already seasoned and do not check, split or warp in service. Maintenance is not usually needed. They require the minimum of fastenings, and assembly and erection costs are low. Furthermore, they are stronger and stiffer than sawn timbers.

The first major attempt at applying engineering analysis to glulam construction in the United States was made in 1935 by T. R. C. Wilson of the U. S. Forest Products Laboratory, Madison, Wisc. Then, in 1943, the War Production Board issued a design directive raising working stresses of timbers twenty per cent, and containing excellent, but preliminary, glulam design principles. Soon thereafter, the National Lumber Manufacturers Association adopted these values and reissued the information as the "National Design Specification for Stress-Grade Lumber and Its Fastenings".

The Forest Products Laboratory embarked upon an extensive research program to determine if the new stresses were safe. In 1948, the Laboratory completed the tests and, after analyzing results, said they were in substantial agreement with new values.

Contemporaneously, the FPL carried out research on glulam timbers in 1946 issuing a report, "Laminating of Structural Wood Products by Gluing." In 1947, "Test Report of Glued Laminated Wood Beams and Columns" was published, and in 1949 a preliminary publication on strength and design was formulated. During June, 1949, the fabricators and representatives of lumber associations met in a week-long conference with the FPL researchers and reached an agreement on basic design principles of glulam construction.

The FPL soon will issue its strength and design findings, outlining a new scientific method of evaluating the strength of glulam timbers. The proven basic stress values of dry, clear wood are given and, due to the increased strength for dryness, are found to be higher by the following percentages than those listed for sawn timbers. Bending or tension with grain—25 percent; shear—14 percent; compression across grain—15 percent; compression with grain—40 percent; and modulus of elasticity—13 percent.

Laminations are selected for structural strength and may be additionally chosen for surface appearance where architectural considerations so dictate. Generally, laminations contain strength-reducing characteristics, such as knots, diagonal grain, and such laminating factors as end joints and curvature. Under the new theory advocated by the FPL, the flexure working stress permitted for a glulam beam will be close to the amount obtained by multiplying the basic stress by the ratio of the moment of inertia of the net section (with knots removed) to that of the gross section. For columns and tension members, the ratio of areas should be used instead of moments of inertia. Slope of grain and lamination end joints are assigned at reducing values and are combined with knot areas for total reduction.

THE FESTIVAL BUILDING at Lodi, Calif., was framed with eight glued laminated timber arches spanning 130 ft.

Lumber associations are now setting up grades for glulam construction made from commercial grades of planks and boards.

Interim design rules

New, up-to-date information will soon be available. It is certain that interior glulam timbers will be designed for approximately the increased percentages over sawn pieces of the same species and grade as previously given for dry, clear wood. Exterior glulam timbers will be designed for the same stresses as are used for sawn timbers since no increased strength for dryness is allowable. For all glulam timbers, short-duration load stress increases, such as for impact, earthquake, wind and snow, may be used as permitted for sawn timbers.

Glulam members should be designed with the same standard engineering formulas as used for sawn. Curved portions, however, should have bending stresses modified by: $1 - 2{,}000\,(t/r)^2$, where t is the thickness of lamination in inches and r is the radius of curvature in inches.

In strength computations, actual net sizes of glulam timbers should be used. It should be noted that the net or surfaced sizes of these members are not necessarily identical with those of sawn pieces. While nominal widths may be the same, net widths are less, since the completed members are planed for appearance sake. Net depth may be any multiple of lamination thickness.

Net widths currently used are 3¼, 5¼, 7, 9, 11 and 12½ in. Net surfaced sizes are acceptable as complying with the nominal sizes established for building code requirements. For example, the 5¼-in. size may be considered as 6-in. nominal.

Laminating requirements

Lumber for glulam timbers should be seasoned to a moisture content that closely approximates that of service conditions, but to not less than seven percent nor more than sixteen percent. Spread between high and low moisture content among the laminations in any one timber should not exceed five percent.

Laminations should be machine finished, but not sanded, to a smooth surface, the maximum variation in dimension being 1/64 in. Warp, twist, cup or other characteristics that prevent intimate contact or good gluing should not be permitted.

Drying facilities of lumber do not now permit economical lamination thickness greater than 2 in. nominal for commercial laminating operations. This maximum is used for truss chords and straight or cambered beams effectively and economically.

To make curved timbers, laminations must be bent dry without injury. Therefore, the greater the curvature, the thinner the laminations must be, and the higher the cost will rise. Consequently, it is highly important that designers keep the minimum radius to as large a figure as clearance permits.

For Douglas fir lumber, laminators restrict curvature to the following thicknesses of laminations. Values are in inches.

Thickness	Curvature
1/4	25
5/16	36
3/8	48
1/2	72
5/8	92
3/4	112
1 1/16	190
1 1/2	250
1 5/8	276

Glulam members stressed principally in bending may be constructed with lower grades of lumber for inner zones without strength reduction. Engineering analysis of specific cases would indicate the material to be provided in each zone to meet strength requirements. Much used is an arrangement in which a lower grade is placed in the center three-fifths of the depth. Zone selection has no merit for members used as ties or columns where tension or compression with the grain is the principal action, nor is it necessarily useful where deflection or shear is critical. Working stresses can be enhanced for all members by judicious specification of close-grained or dense material.

Suggestions for gluing

Laminations may consist of one piece, or two or more pieces placed side by side to the full width. In the latter case, edge joints should stagger at least 2 in. in a lateral direction. For exterior timbers, laminations should be either one-piece or the outer ones edge-glued.

Gluing operations should comply with the glue manufacturer's recommendations as to control of temperature, moisture content of materials, mixing and spreading of glue, pressure, assembly time, and suitability of glue for materials, treatments and service conditions involved. Good glue bond should be attained throughout the surfaces joined. (Field gluing is not conducive to good work, because here weather, untrained personnel and inadequate equipment are always present to some degree, and impose handicaps that lower quality.) Where the shape of laminations permits, the glue should be applied by mechanical spreaders and to uniform thickness.

The pressure should be at least 75 psi. with the clamps being spaced to apply it as uniformly as practicable. Use of nails to apply gluing pressure is not satisfactory because they cannot provide the intensity nor uniformity needed. Also, the addition of stitch bolts to strengthen glue lines is of no avail since mechanical fastenings of any sort become effective only after some slippage has occurred, and thus the glue lines would have to fail before the bolts became operative.

Glulam timbers, like plywood, are made in two types—interior and exterior. Used where moisture contents will not exceed 20 percent, interior timbers may be fabricated with water-resistant glues, such as urea or casein. The limiting moisture content for urea glues should be reduced when service is expected to be a combination of high temperature and a relatively high humidity. Since members for moisture contents of less than 20 per cent are not subjected to a decay hazard, preservative treatment is not needed.

For exterior timbers, which are used where moisture contents may be more than 20 percent, waterproof glues, such as phenolic resin, must be applied. Exterior timbers may be subjected to a decay hazard, and preservative treatment may be advisable. A pressure oil or water-borne preservative or fire-retardant treatment can be applied without injury to glue lines after the timbers have been laminated. Although treatment of laminations before assembly has not yet been explored fully, many items have been so constructed, and this method is often advantageous. Tests indicate that oil preservatives such as creosote, if not too heavy on surfaces, will not prevent good bond with waterproof adhesives. Also, some water-borne preservatives and fire-retardants appear to be compatible with certain glues, so that adequate bond is obtained when laminations are treated prior to gluing.

Water and oil treatments, however, cause surface disturbances, warping and dimension changes, and leave surface deposits on laminations that may make resurfacing necessary after treatment. Resurfacing must be done lightly, or too much treatment is removed. Redrying operations may also be required.

Appearance-type members should receive protective wrapping or crating to safeguard their surfaces during shipment and during construction. Interior members that might be subjected to adverse moisture conditions prior to being permanently housed in a dry location should be protected with a waterproof wrapping or should be given a moisture-resistant coating. All members should have an application of moisture seal applied at the ends.

How to keep costs down

The purchaser's price and size requirements govern glulam operations and selection of materials. Hence, for economy, specifications for appearance and durability should be adequate but not excessive. Perhaps some faces can be left unplaned, or other refinements simplified. Shop protective coatings should not be applied to members to be given field stains, nor should fire-retardant or preservative treatments be used when not really needed. Neither should exterior timbers be specified for interior service.

Inspection to comply with codes or purchaser's specifications may be provided by lumber inspection agencies equipped with qualified inspectors of glued lamination. Qualified laminators also maintain products controls and inspections to assure required quality at all times.

Grading and dressing rules of regional lumber associations and publications of the Timber Engineering Co., Washington, D. C.; National Lumber Manufacturers Association, Washington, D. C.; West Coast Lumbermen's Association, Portland, Ore.; Southern Pine Association, New Orleans, La.; and Forest Products Laboratory, Madison, Wis., are of invaluable assistance to timber designers.

In addition, an American Institute of Timber Construction is now being organized and will be announced in the near future. The AITC will disseminate information on standard practices for structural timbers and timber construction accessories. For individual design problems the National Design Specification for Stress Grade Lumber and Its Fastenings" published by the National Lumber Manufacturers Association should be consulted.

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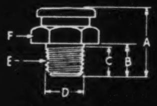

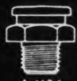
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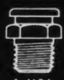
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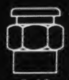
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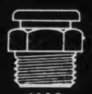
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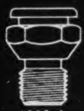
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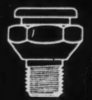
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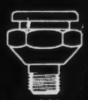
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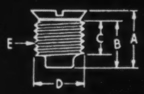

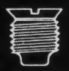
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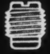
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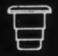
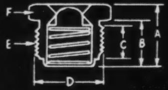
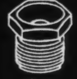

Z-730-A

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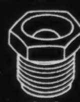
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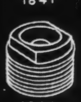
1846

Useful Data Sheet to Help You Select and Specify the Right Alemite Fitting for Every Bearing on Construction Equipment.

STANDARD BUTTON HEAD FITTINGS

Part No.	DIMENSIONS					
	A	B	C	D	E	F*
C-69	29/32"	13/32"	9/32"	39/64"	1/8" P.T. Female	5/8"
A-1184	3/4"	11/32"	19/64"	13/32"	1/8" P.T.	5/8"
A-1186	53/64"	27/64"	3/8"	35/64"	1/4" P.T.	5/8"
A-1188	61/64"	31/64"	27/64"	43/64"	3/8" P.T.	3/4"
A-1190	1 5/64"	35/64"	31/64"	27/32"	1/2" P.T.	7/8"
1396	1"	1/2"	13/32"	43/64"	3/8" P.T.	3/4"
1401	53/64"	27/64"	3/8"	35/64"	1/4" P.T.	5/8"

*Wrench Size.

GIANT BUTTON HEAD FITTINGS

Part No.	DIMENSIONS					
	A	B	C	D	E	F*
1820	1 1/16"	1/2"	13/32"	27/32"	1/2" P.T.	7/8"
1821	1 5/16"	9/16"	7/16"	5/8"	5/8"-18 Thd.	7/8"
1822-A	1 5/16"	9/16"	29/64"	43/64"	3/8" Spec. P.T.	7/8"
1823	1 1/4"	1/2"	3/8"	35/64"	1/4" P.T.	7/8"
1825	2"	41/64"	11/32"	43/64"	3/8" P.T.	7/8"
1831	1 5/32"	3/8"	9/32"	13/32"	1/8" P.T.	7/8"
**1871-A	1 5/16"	9/16"	29/64"	43/64"	3/8" P.T.	7/8"
**1872-A	1 1/4"	1/2"	3/8"	35/64"	1/4" P.T.	7/8"

*Wrench Size. **1871-A and 1872-A have special construction to withstand extremely high pressures. Recommended for use on lubricated valves.

FLUSH TYPE FITTINGS

Model No.	A	B	C	D	E
†Z-730-A	7/16"	3/8"	....	5/16"	....
Z-741-A	9/16"	15/32"	7/16"	35/64"	1/4" P.T.
1452	1/2"	29/64"	29/64"	13/32"	1/8" P.T.
†1814	21/64"	9/32"	....	5/16"	....
1815	23/64"	9/32"	9/32"	13/32"	1/8" P.T.
†1817	11/32"	19/64"	....	3/8"	....
†1853	11/32"	19/64"	....	1/4"	....

†Drive Fittings.

GIANT FLUSH TYPE FITTINGS

Model No.	A	B	C	D	E	F*
1840	49/64"	39/64"	31/64"	5/8"	5/8"-11 Thread	3/4"
1841	49/64"	39/64"	31/64"	43/64"	3/8" P.T.	3/4"
1842	55/64"	39/64"	1/2"	27/32"	1/2" P.T.	7/8"
1843	7/8"	39/64"	1/2"	1 3/64"	3/4" P.T.	1 1/8"
1844	7/8"	5/8"	31/64"	1 5/16"	1" P.T.	1 3/8"
**1846	49/64"	19/32"	19/32"	1 3/64"	3/4" P.T.	11/16"
**1847	55/64"	39/64"	1/2"	27/32"	1/2" P.T.	3/4"

*Wrench Size. **Flush Fit No Hex.

FREE REPRINTS—You may obtain a complete set of these data sheets covering all Alemite Fittings.

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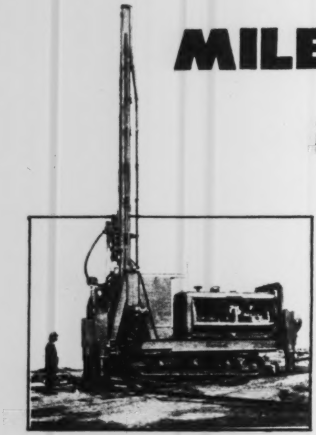
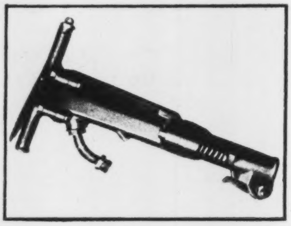


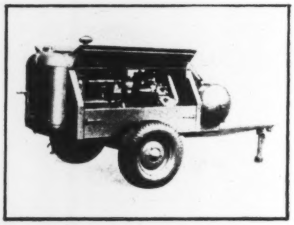
1 The revolutionary ***Quarrymaster Drill,*** introduced by Ingersoll-Rand in 1947, has opened new opportunities for speed and economy in open pit mining, quarrying and road building. This self-contained unit includes the drill, compressor, power unit and accessories. With Carset Bits, the Quarrymaster out-drills conventional equipment by as much as . . .

☐ **2 to 1**
☐ **4 to 1**
☐ **10 to 1**



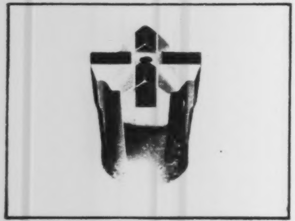
2 The ***paving breaker*** is probably the most universally used of all air power tools. You'll find it doing yeoman service on all kinds of construction, demolition and maintenance work. Ingersoll-Rand has been building these light-weight, high-powered tools since 1911. As compared to hand methods, one paving breaker can do the work of . . .

☐ **2 men**
☐ **15 men**
☐ **5 men**



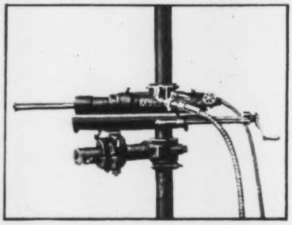
3 This modern I-R ***portable compressor***—known the world over as the Mobil-Air—is the descendant of a long line of portables, which first appeared in our catalog in 1902. Ingersoll-Rand has pioneered every major advance in portable compressors in the last 47 years — including the I-R Drill-More regulator which was introduced in . . .

☐ **1939**
☐ **1948**
☐ **1932**



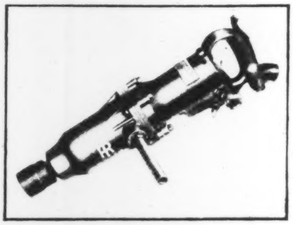
7 The ***Carset Jackbit,*** with inserts of tungsten carbide, was introduced by Ingersoll-Rand in 1946 and is acclaimed by many operators as the greatest single advance in modern rock drilling history. Its performance and cost saving features are truly spectacular. Under average conditions, it will outlast a steel bit usage by . . .

☐ **25 to 1**
☐ **50 to 1**
☐ **100 to 1**



8 Many old timers will recognize this as J. George Leyner's ***hammer drill*** — it was the first successful application of the hammer principle, using hollow drill steel through which air and water were directed to remove cuttings. The Leyner Company was consolidated with Ingersoll-Rand in the early development stage of this drill, which was introduced in . . .

☐ **1897**
☐ **1887**
☐ **1907**



9 Ingersoll-Rand's labor-aiding rotary ***Impactool*** reduces nut running time as much as 90 per cent, without any kick or twist to the operator — speeds up drilling, reaming and tapping jobs, too. Models are available for operation by either air power, high-cycle electric or universal electric power. Under ordinary conditions, an Impactool can pay for itself in . . .

☐ **20 days**
☐ **30 days**
☐ **90 days**

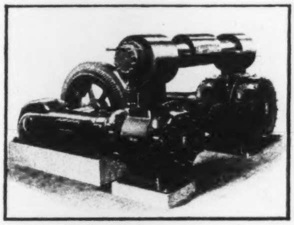
OVER 75 YEARS OF SPECIALIZED EFFORT

Pictured on these pages are ten typical Ingersoll-Rand products commonly used by contractors. Some are new—some are old. But each one represents an important milestone of progress in the construction field.

Many of you will remember from your own experience the approximate date on which these products were introduced, also other interesting facts about them.

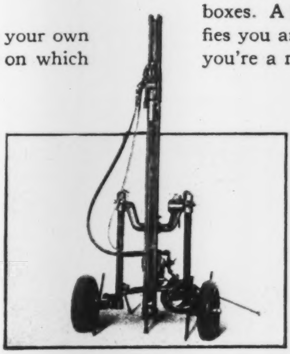
Now, just for the fun of it, see how many of the questions below you can answer correctly . . . place a check mark in the proper boxes. A score of five is good. Seven qualifies you an expert. If you get all ten right, you're a real "Hard Rock Man!"

See answers below



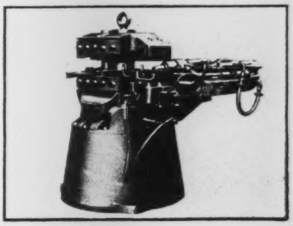
4 The ***channel valve,*** which raised compressor efficiency to new heights, and the first direct-connected, synchronous-motor-driven compressors are but a few of many improvements pioneered by Ingersoll-Rand during the past 70 years. The famous channel valve was introduced on one of the following dates:

- ☐ **1935**
- ☐ **1920**
- ☐ **1915**



5 In 1920 the first Ingersoll-Rand ***wagon-mounted drill*** was placed on the market. Today, I-R Wagon Drills are making lighter work of construction jobs all over the world — saving time and effort and increasing the footage drilled per shift. On the average, they will out-drill hand-held drills by . . .

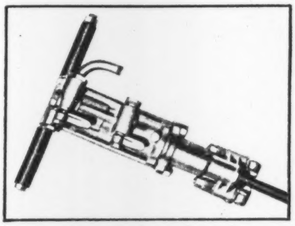
- ☐ **2 to 1**
- ☐ **5 to 1**
- ☐ **1½ to 1**



6 Forging of bits and shanks by hand was an art mastered by few. It was hard work and the results were far from accurate. But hand forging was eliminated when Ingersoll-Rand developed the ***drill steel sharpener.*** A good sharpener operator working on collared shanks can usually beat hand methods by . . .

- ☐ **10 to 1**
- ☐ **16 to 1**
- ☐ **20 to 1**

ANSWERS:
(1) 10 to 1, (2) 15 men, (3) 1939, (4) 1935, (5) 5 to 1, (6) 16 to 1, (7) 100 to 1, (8) 1897, (9) 30 days, (10) 1912.



10 Every rock drill man is familiar with the ***Jackhamer***. But perhaps few stop to realize that its development was one of the most important steps in rock drilling. For this hand-held drill replaced slow and expensive piston drills and made all hand drilling obsolete. The first automatically rotated, hand-held Jackhamer was introduced by Ingersoll-Rand in . . .

- ☐ **1912**
- ☐ **1900**
- ☐ **1920**

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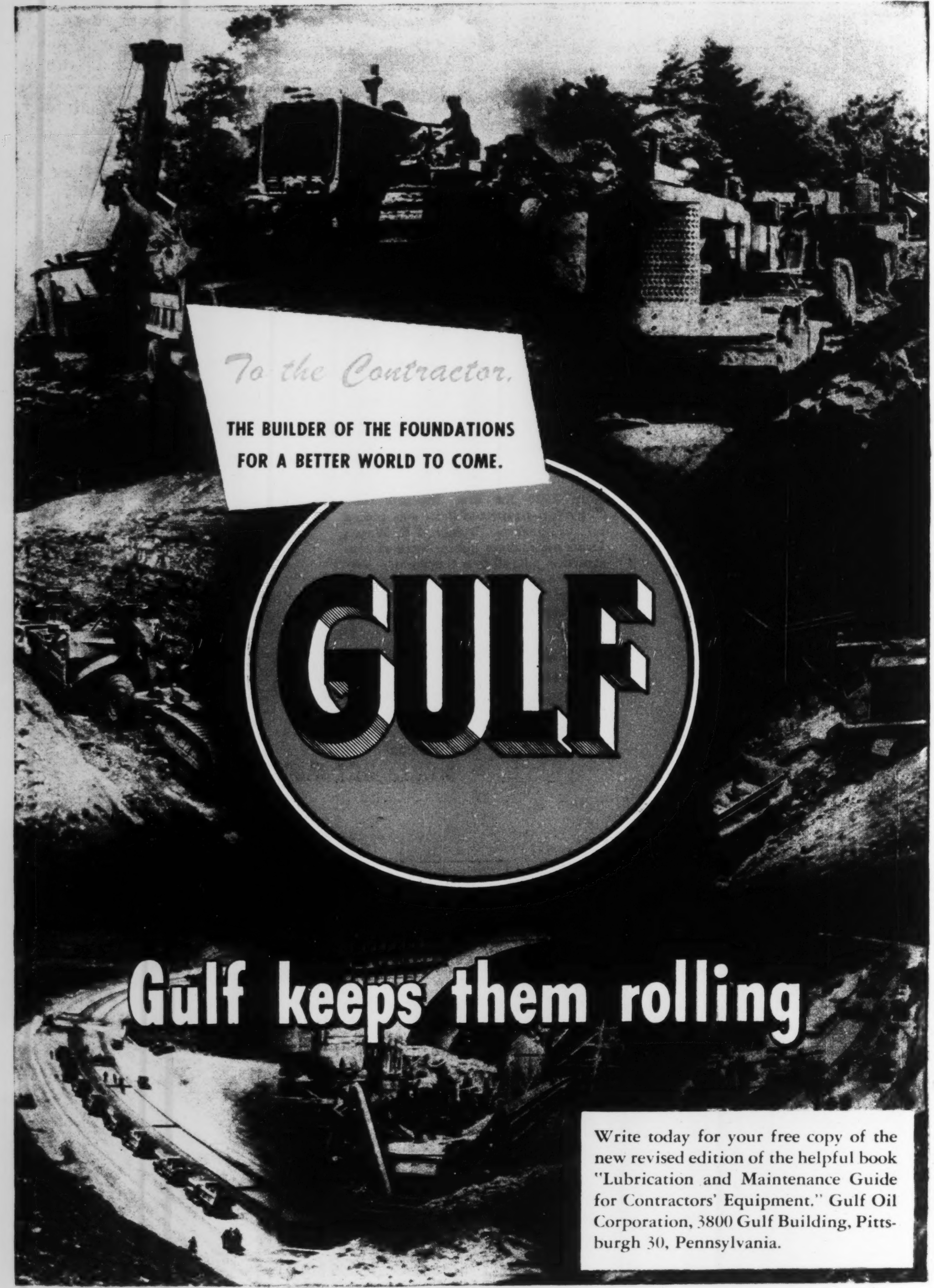
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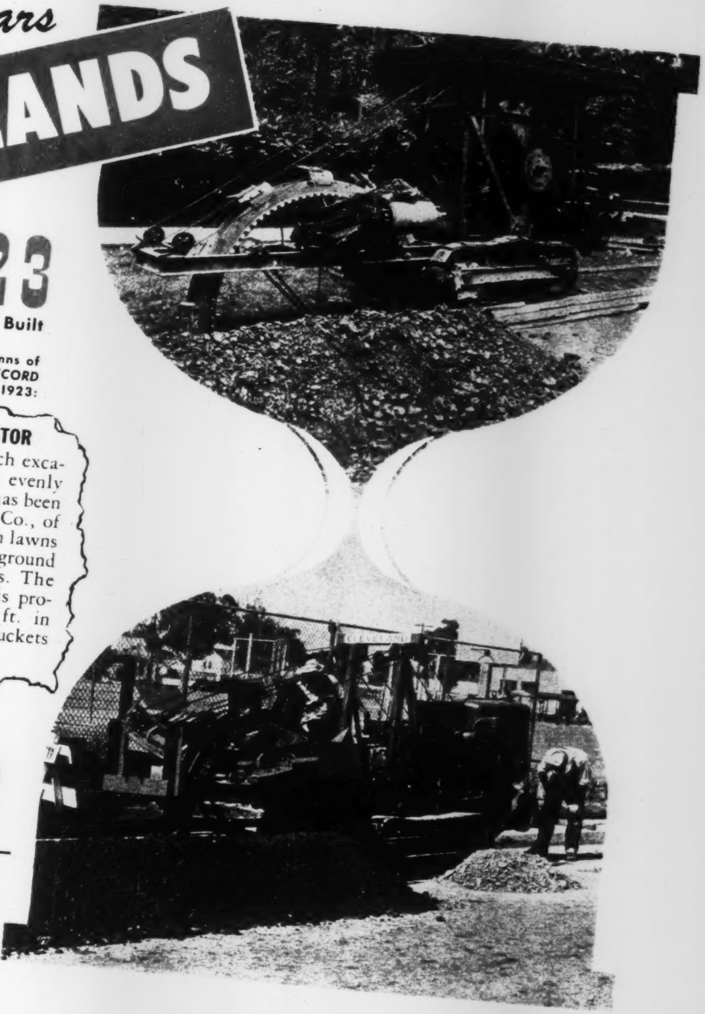

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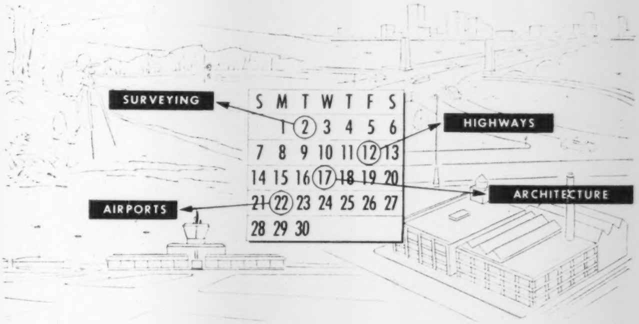
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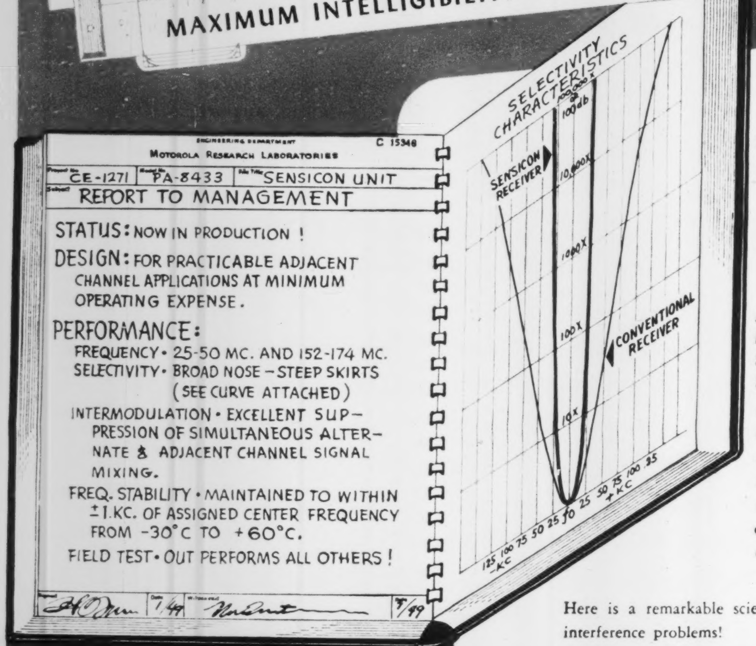

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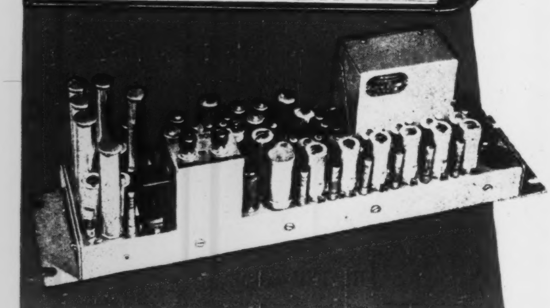

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FLINTKOTE INDUSTRIAL PRODUCTS

THE FLINTKOTE COMPANY, *Industrial Products Division*
30 Rockefeller Plaza, New York 20, N. Y.

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9 California East Bay Cities Served By Allis-Chalmers

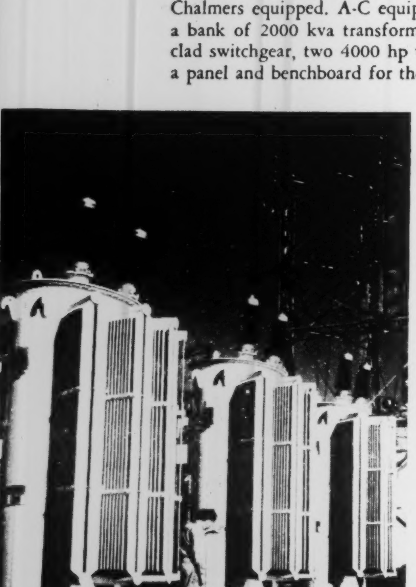
NEW BOOSTER PUMPING STATION IS EQUIPPED WITH A-C SWITCHGEAR, CONTROL PANELS, TRANSFORMERS AND MOTORS

WITHIN EIGHT YEARS, water consumption in the East Bay Municipal Utilities District has increased 134 percent. To meet this rising demand a new booster pumping station was constructed on the 94 mile Mokelumne Aqueduct. Combined with older facilities, this new station more than meets the water demands of the district.

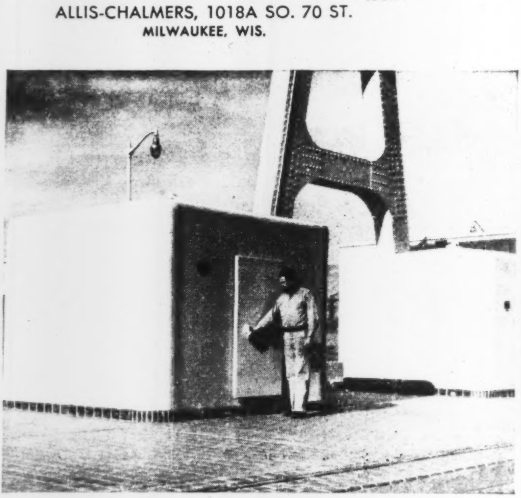
The electrical system of the new station is Allis-Chalmers equipped. A-C equipment here includes a bank of 2000 kva transformers, outdoor metal-clad switchgear, two 4000 hp vertical motors, and a panel and benchboard for the control room. Installed in 1945, this equipment has given efficient, reliable service.

This A-C equipped station is typical of what Allis-Chalmers can do and has done for all size cities — large, medium and small. When your community plans improvements, take advantage of Allis-Chalmers specialized knowledge in building the world's widest range of public works equipment. For more information write for bulletin 25B6607, "Public Works Equipment." A-2777

ALLIS-CHALMERS, 1018A SO. 70 ST.
MILWAUKEE, WIS.



BANK of Allis-Chalmers single phase, 2000 kva power transformers at new pumping station of East Bay District. Units are equipped with no-load tap changers, side mounted for easy, simple changes. Transformers are also designed with *Oil-Sealed* inert gas systems which seal off cooling oil from outside air. This reduces contamination of cooling oil and prevents deterioration.

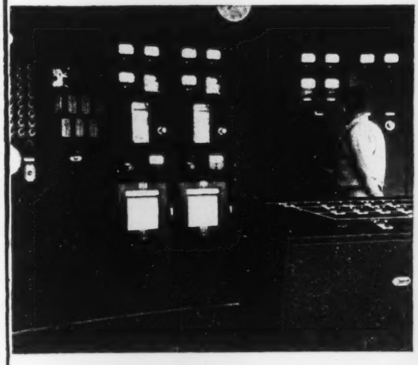


4000 HP, 900 RPM vertical motors drive centrifugal pumps. These motors were assembled at the site and enclosed in special weatherproof housings to insure safe outdoor operation. Motors and streamline housings were built by A-C.

Ruptair and *Oil-Sealed* are Allis-Chalmers trademarks.

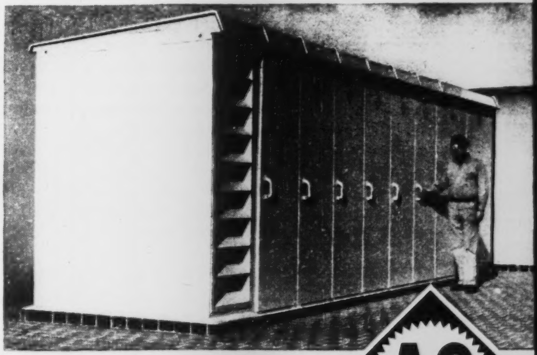
AREA SERVED by the East Bay Municipal Utility District includes Alameda, Albany, Berkeley, El Cerrito, Emeryville, Oakland, Piedmont, Richmond and San Leandro. Total area: 187 sq miles with a population of nearly one million. A portion of this area is shown above with Oakland-San Francisco Bay Bridge in the foreground.

Photo by Commercial & Photo View Company, Oakland, Cal.



MODERN type control switchboard and benchboard were designed by Allis-Chalmers to provide this station with reliably accurate automatic remote control.

PROTECTION for two 4000 hp motors is provided by outdoor metal-clad switchgear with *Ruptair* magnetic air circuit breakers rated 100,000 kva interrupting capacity.

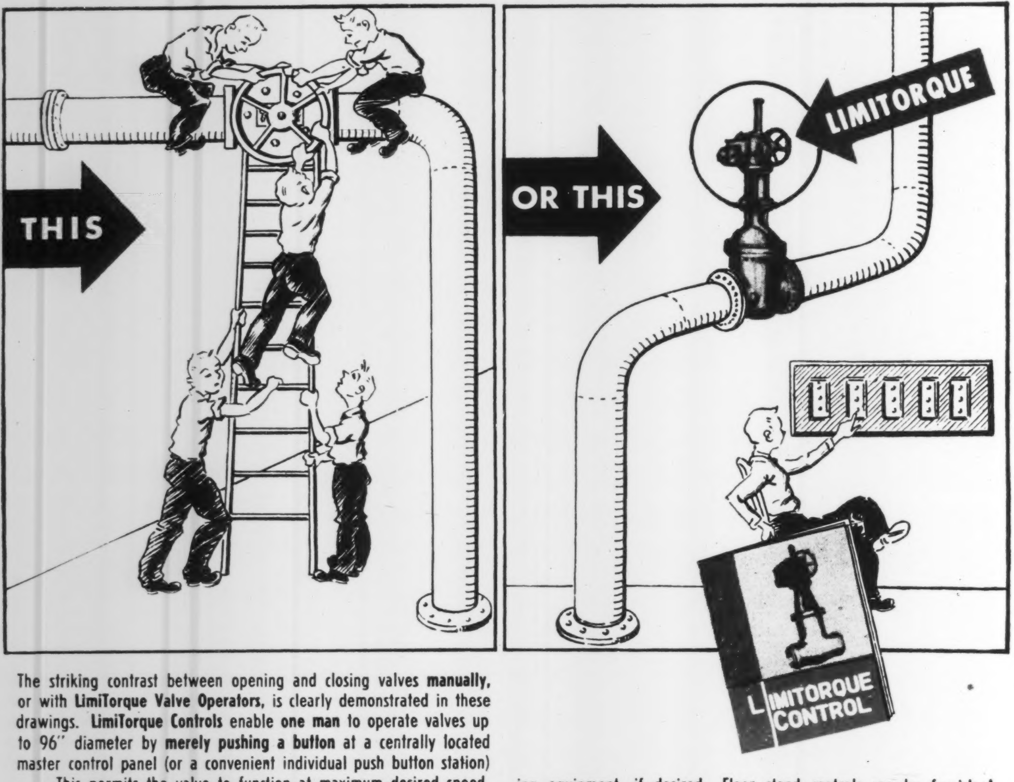


ALLIS-CHALMERS

Builders of the World's Widest Range of Public Works Equipment

Which method of valve operation is safe, sure..

...and **SAVES** *time... trouble... money...*



The striking contrast between opening and closing valves **manually**, or with **LimiTorque Valve Operators**, is clearly demonstrated in these drawings. **LimiTorque Controls** enable **one man** to operate valves up to 96″ diameter by **merely pushing a button** at a centrally located master control panel (or a convenient individual push button station) . . . This permits the valve to function at maximum desired speed, while eliminating all physical efforts and hazards to the workmen.

Remote operation of valves from one central point, with a full knowledge of their **status at all times**, is possible with **LimiTorque**. There are several types of **LimiTorque Controls** applicable for operating all types and sizes of valves, and which can be adapted to existing equipment, if desired. Floor stand controls can be furnished where it is not practical to fit the controls directly to the valve yokes.

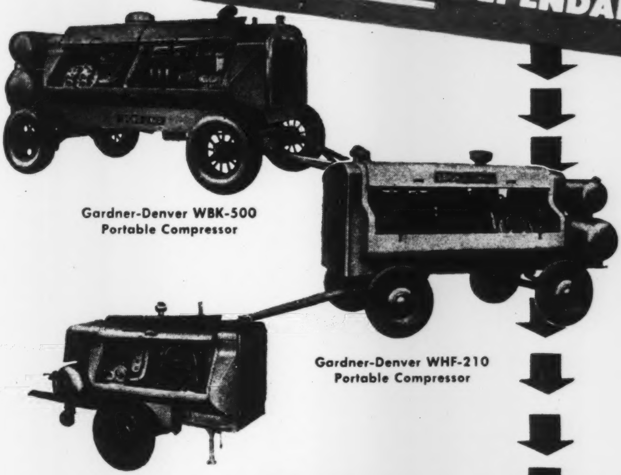
Thousands of **LimiTorques** are used in water and sewerage works, central stations, private power plants, oil pipelines and refineries, on ships, etc. Send for our 96-page catalog, and please use your Business Letterhead when writing for same.

Philadelphia Gear Works, INC.

ERIE AVE. AND G ST., PHILADELPHIA 34, PA.
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON
IN CANADA: WILLIAM AND J. G. GREEY LIMITED, TORONTO

Industrial Gears and Speed Reducers
LimiTorque Valve Controls

AN ALWAYS DEPENDABLE AIR SUPPLY . . .



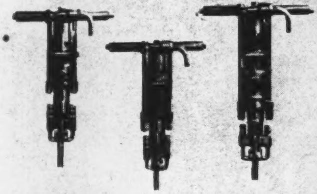
Gardner-Denver WBK-500
Portable Compressor

Gardner-Denver WHF-210
Portable Compressor

Gardner-Denver WHD-105
Portable Compressor

No matter where you send a Gardner-Denver Portable Compressor, you can be sure of a steady, uninterrupted air supply. For regardless of climate or altitude, the complete water jacketing of all cylinders "weather-conditions" them against over-heating — and from cold, unlubricated starts in sub-zero weather. For complete information, write Gardner-Denver Company.

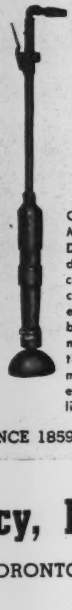
. . . FOR THE RIGHT AIR TOOLS



There's a Gardner-Denver Sinker that's "correct" in size and power for every type of ground. Shown here are the three most popular models: the high-speed S45 for secondary drilling or medium rock—the S55, most popular 55-pound sinker on the market—the S73, 67 pounds of speed and power for deep holes or the hardest formations.

Powerful Gardner-Denver B87 Paving Breaker has exclusive throttle safety latch — can be easily moved around the job without shutting off the air. Easily converted to a sheeting driver.

The feed of the new Gardner-Denver URM99 Wagon Drill is powered by a five-cylinder radial air motor. Designed for speedy, six-foot steel changes; carries a 3½ in. or 4 in. bore derrick drill. Your operator will like the ease of control.



The Gardner-Denver T23 Backfill Tamper is balanced for easy "walking" over the fill — has valve and exhaust that won't "freeze" in cold, damp weather — contains integral oil reservoir that assures complete lubrication.

Gardner-Denver Model 28 Clay Digger makes digging easy in clay or hardpan—can also be equipped with axe blade for trimming or cutting timber, or with moil point or chisel for light demolition work.

GARDNER-DENVER SINCE 1859

GARDNER-DENVER Company, Quincy, Illinois

IN CANADA: GARDNER-DENVER COMPANY (CANADA) LTD., TORONTO, ONTARIO

CONTRACTORS BUY DODGE -save money

SAVE . . . with these many money-saving features

ENGINES . . . of famous Dodge L-head design save gas, oil, service expense. Full-pressure lubrication, full-length cylinder cooling, and replaceable prefitted main bearings reduce upkeep, prolong life.

CHASSIS . . . Super-friction clutches, with extra large frictional area; rugged 3-, 4- and 5-speed transmissions; full-floating, hypoid rear axles give better performance, insure longer life. Cross-type steering permits sharper turning, easier handling. Cyclebonded brake linings (no rivets) insure safer stops, prolong lining wear.

CABS . . . Adjustable "Air-O-Ride" seats. Roomy, wide-vision "Pilot-House" cabs, with rear quarter windows, extra-wide seats and "All-Weather" ventilation, insure maximum vision, comfort and safety.

You save money when you buy Dodge *"Job-Rated"* trucks!

There are two reasons for this:

1. Your truck has more money-saving features than any other make of truck built. Many of these are *exclusive* Dodge features.
2. Your *"Job-Rated"* truck is built to fit its job. And trucks that fit the job save on operating costs. They last longer!

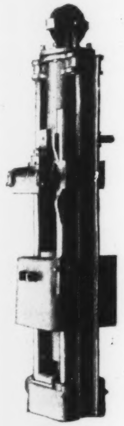
Read (at left) a partial list of Dodge truck features that are important to you. Then—see your Dodge dealer for *all* the reasons why a Dodge *"Job-Rated"* truck (priced with the lowest) is the best truck investment you can make.

Priced with the lowest

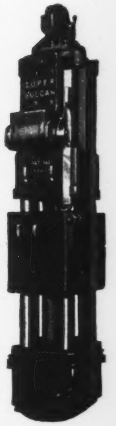
For the good of your business—

Switch to DODGE "Job-Rated" TRUCKS

VULCAN PILE HAMMERS



The WARRINGTON - VULCAN Single Acting Steam Pile Hammer is a powerful, dependable machine operating at medium steam pressure with rapid, regular and continuous action. It is readily adapted to driving wood, concrete, steel or pipe piles.



The SUPER-VULCAN Open Type Differential-Acting Pile Hammer packs all the power you'll ever need. It delivers twice as many blows on 25 to 35 per cent less steam. It fits the same leads and uses the same accessories.

Over 60 years on tough jobs and

STILL DRIVING HARD!

What a record! Vulcan Pile Hammers built in 1887 are driving piles today on important construction jobs. They're still driving hard because they were built strong to last long. In its modern machines, Vulcan has added to this amazing durability greater efficiency, ease and economy of operation so popular with regular users.

Vulcan Pile Hammers are designed to meet the requirements of experienced contractors. They've been tested and proved on tough jobs all over the world. And they're built to a scientific standard which Vulcan pioneered.

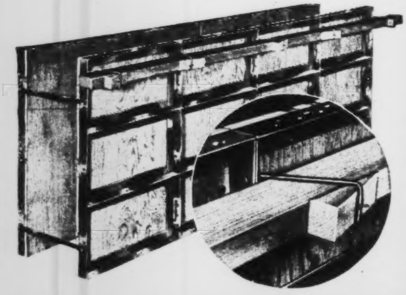
No wonder Vulcan Pile Hammers are favorites. They have played and they continue to play a positive part in the progress of engineering and construction.

Write for a free catalog on the pile hammer that lasts a lifetime.

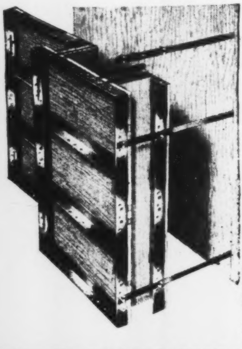
VULCAN IRON WORKS

331 North Bell Avenue Chicago 12, Illinois

UNI-FORMS the

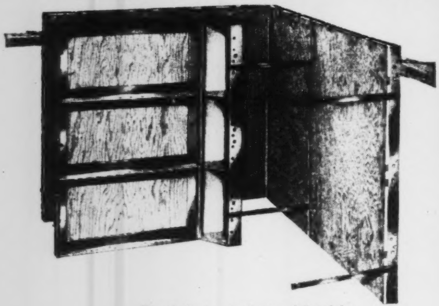


1 side alignment only . . . kept to a minimum. Save TIME...Save MATERIAL

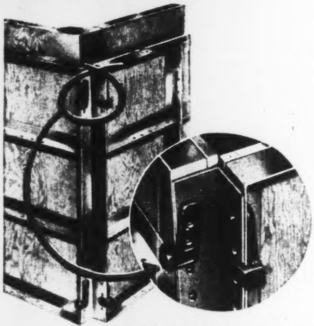


Pilasters easily formed with 3-Loop Uni-Form Tie in one simple operation. FASTER ERECTION . . . LOWER COSTS

FOOLPROOF ASSEMBLY

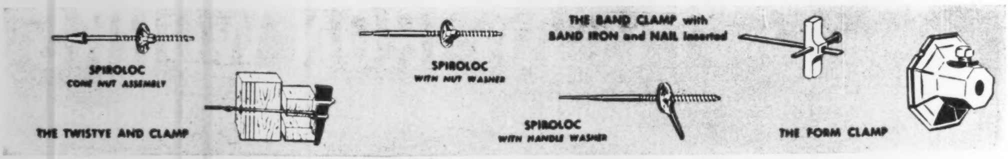


Prefabricated steel inside corners . . . the *simplest* method of corner forming.



Outside corners . . . a corner angle and a Panel Loc = an accurate, vertical corner. EASY . . . POSITIVE.

UNI-FORMS mean...faster erection...faster stripping... lower all around costs on any concrete job


SPIROLOC
CONE NUT ASSEMBLY
THE TWISTYE AND CLAMP
SPIROLOC
WITH NUT WASHER
THE BAND CLAMP with
BAND IRON and NAIL Inserted
SPIROLOC
WITH HANDLE WASHER
THE FORM CLAMP

modern way to form concrete!

MEET TODAY'S CHALLENGE FOR TOMORROW'S ACHIEVEMENT

Build Better... faster at lower cost

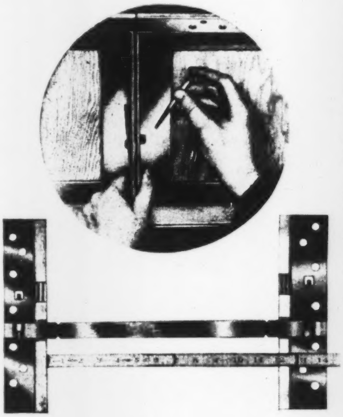
America's Builders are solving today's problems of higher labor and material costs by streamlining and simplifying every phase of construction . . . are building better, faster at lower cost by using modern methods to speed their work

UNI-FORMS . . . the prefabricated, ready-to-use system of forming concrete, are providing the simplicity, speed and low cost so vitally necessary today. Automatically accurate forming . . . easy adaptability to any job . . . reduced material requirements *always* insure faster forming and lowest all-around cost.

RENTED . . . SOLD . . . or RENTED WITH A PURCHASE OPTION

Try **UNI-FORMS** on *your* next job. See for yourself why **UNI-FORMS** can do the best job for you . . . today . . . tomorrow.

The new **UNI-FORM** Catalog tells the whole story. Write for it . . . there is no obligation.



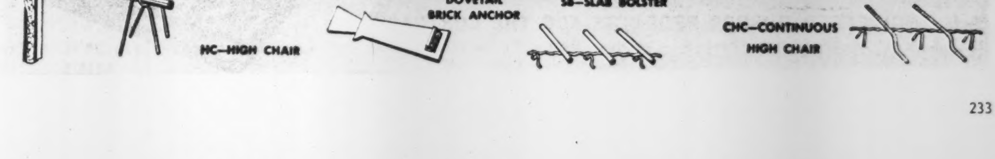
Automatic ACCURACY

Uni-Form Ties and Tie Keys lock, spread and tie **UNI-FORMS** into a tight, rigid form with automatic accuracy . . . positive wall thicknesses from top to bottom are guaranteed.

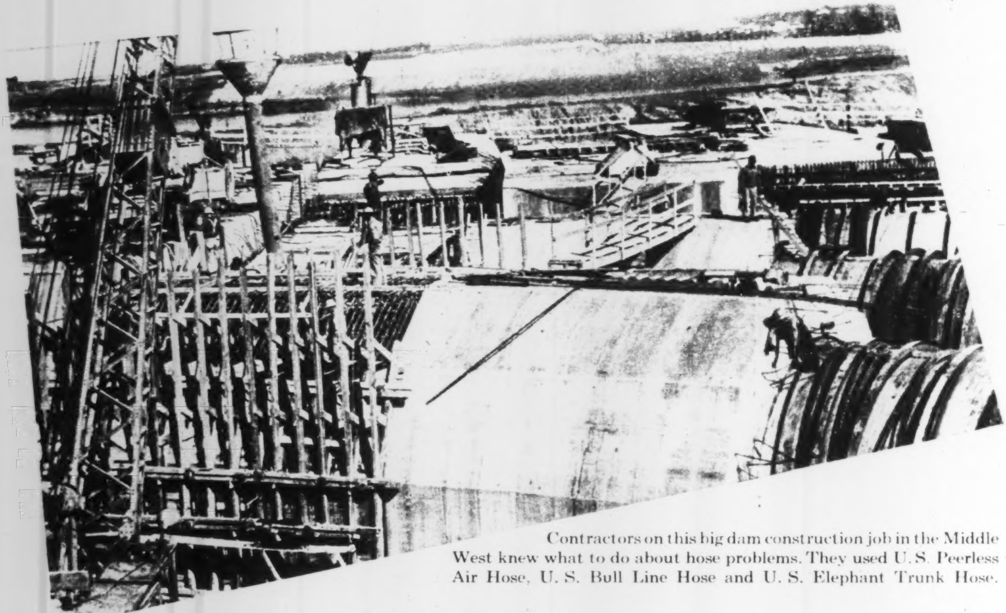
see UNI-FORMS

on your desk . . . 16mm films. with our compact projector and screen bring you **UNI-FORMS** in action.

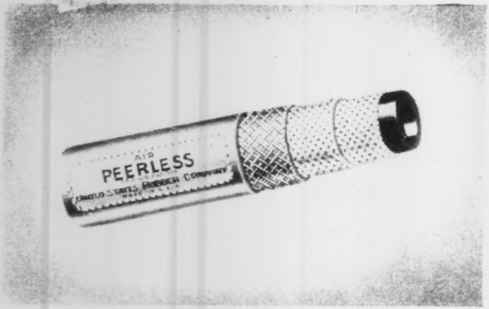
UNIVERSAL
Form Clamp Company
FOUNDED 1912
1238 N. KOSTNER CHICAGO 51



For rough, tough work—it's "U. S." Hose!



Contractors on this big dam construction job in the Middle West knew what to do about hose problems. They used U. S. Peerless Air Hose, U. S. Bull Line Hose and U. S. Elephant Trunk Hose.



U. S. PEERLESS AIR HOSE has oil-proof synthetic rubber lining, and a tough, flexible, brown rubber cover with a resilient surface workmen like to handle. Tube is specially compounded to take both hot and cold oil without swelling or flaking.

U. S. BULL LINE HOSE carrying air from compressor to manifold in air tool contract work. It is widely used for portable compressor work. Extra high pressure. Standard for tunnel contractors.

U. S. ELEPHANT TRUNK HOSE—wherever considerable quantities of concrete are poured, U. S. Elephant Trunk Hose provides an ideal method for dropping it speedily and efficiently into the proper spot.

Since the hose is flexible, it can easily be maneuvered and led into inaccessible places where concrete could not be dropped directly.

For more information about

U. S. ENGINEERED RUBBER PRODUCTS FOR THE CONTRACTOR

Hose • Belting • Gate Seals and Water Stops • Hydron

Write U. S. Rubber Co., Mechanical Goods Division, New York 20, N. Y.

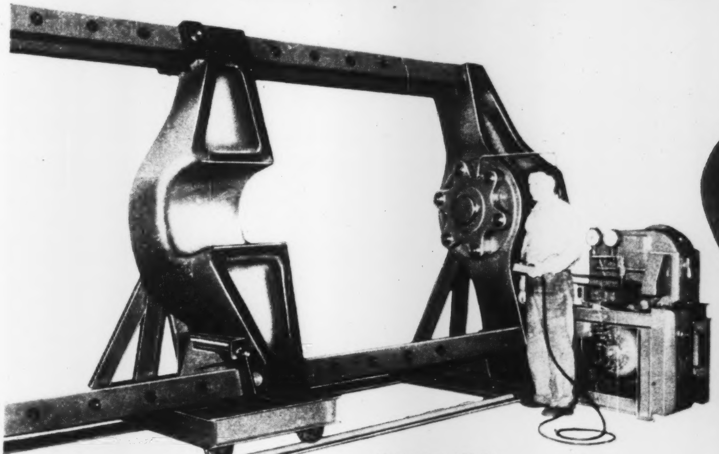
PRODUCTS OF

U.S.RUBBER
SERVING THROUGH SCIENCE

UNITED STATES
RUBBER COMPANY

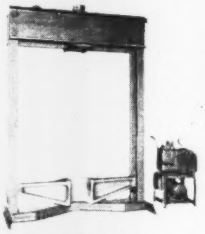
FORCE *for the*

HEAVY JOBS

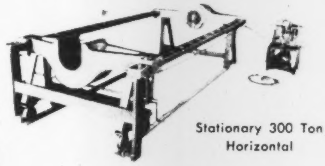


Rodgers Forcing Presses

Stationary 600 Ton
75° Inclined



Open Yoke Vertical
150 Ton



Stationary 300 Ton
Horizontal

100 Ton Portable

Choose from this versatile selection of Rodgers Forcing Presses to meet your requirements for pressing, bending, straightening, forming and other operations. Units can be had either portable or stationary; horizontal, vertical or inclined; 100 to 600 tons! They can be powered with either hand operated or power-driven hydraulic pumps.

For rugged, heavy duty work there are three big 600 ton units—75° inclined, 90° inclined and horizontal. Remote controls are included with the power-driven pumps so that operator may work from any desirable location.

Other stationary forcing presses are available in 200, 300 and 400 ton capacities in horizontal, 75° or 90° inclined. Portable units for versatile plant use are available in 100 and 200 ton capacities, with either hand or power-driven pumps. The open yoke vertical press, as shown, is a specially designed unit to meet your applications.

SEND FOR NEW CATALOG

Full information on Rodgers Forcing Presses is given in New Catalog No. 315. Send for your copy today.

RODGERS FORCING PRESSES

HYDRAULICS Rodgers KEEP THE WORLD MOVING

Rodgers Hydraulic, Inc.

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HYDRAULIC POWER EQUIPMENT

CUMMINS DIESEL
SINCE 1918 PIONEER OF PROFITABLE POWER THROUGH HIGH SPEED DIESELS

Cummins Through The Cut

On a railroad relocation project near Burnside, Kentucky, the Burnside Construction Company, Inc., is using nine Cummins Diesels in slashing a deep cut through a mountain of solid rock. The cut averages 65 feet in depth, 90 feet in width, and is 2,600 feet long.

So far, 170,000 yards of rock have been loaded into rock haulers by a 1201 Lima shovel powered with a Model LI-600 Cummins Diesel. The rock haulers are eight Euclid Rear Dumps . . . all powered with Model HBID-600 Cummins Diesels.

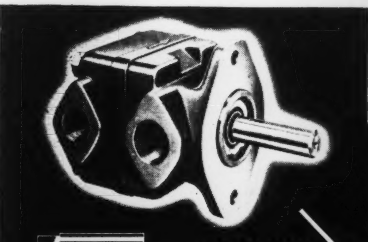
In one three-shift day, 4,123 yards of stone were handled by the Cummins-Powered shovel and hauling units. The round-trip haul that day averaged 5,330 feet . . . over a rough and rocky road.

Can you afford any other power?

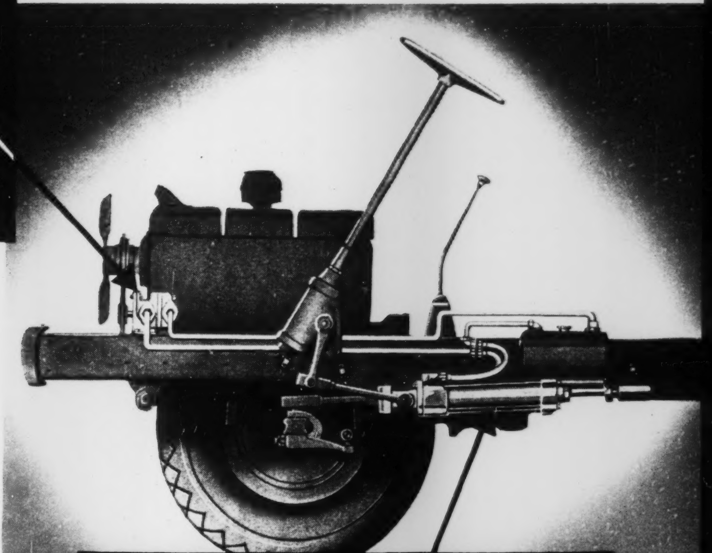
CUMMINS ENGINE COMPANY, INC., COLUMBUS, INDIANA

VICKERS Hydraulic Steering System

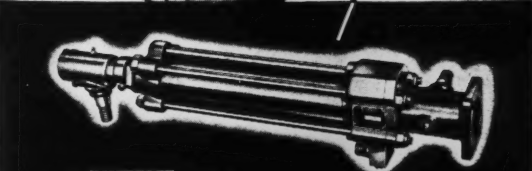
COSTS YOU *20% Less* THAN PREWAR



VICKERS SERIES V-200 BALANCED VANE PUMP
See Bulletin 49-52



At the current low prices, your new models should offer the added sales advantages made possible by VICKERS Steering System



VICKERS HYDRAULIC STEERING BOOSTER with integral overload relief valve . . . *See Bulletin 47-30a*

Improved design, better tooling and production methods of the past 10 years have resulted in a more than 20% price reduction in the Vickers Hydraulic Power Steering System. This saving greatly broadens the application possibilities of the Vickers Steering System.

Important among the many advantages of the Vickers Steering System are safety, effortless steering, adaptability and operator satisfaction. The resulting substantial customer acceptance and preference for Vickers Hydraulic Power Steering System is evident from its specification as original equipment by an increasing number of mobile equipment builders and operators alike.

3987

VICKERS Incorporated
DIVISION OF THE SPERRY CORPORATION
1496 OAKMAN BLVD. • DETROIT 32, MICHIGAN

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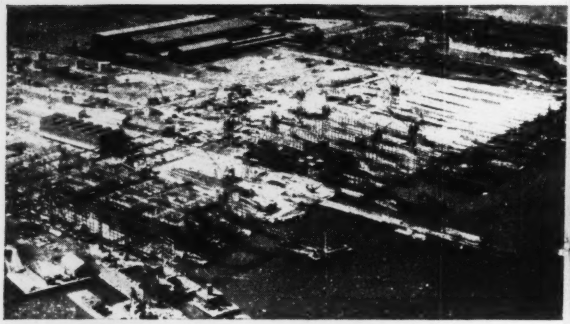
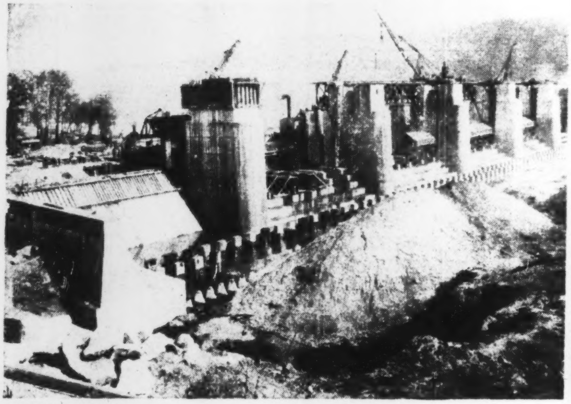
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Booth & Flinn

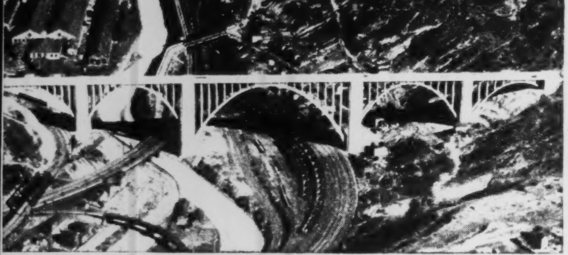
BUILDS FOR A GREATER AMERICA



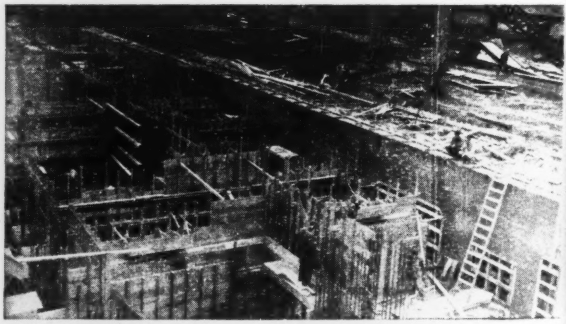
SHIPYARD CONSTRUCTION. 16 shipways made the Bethlehem-Fairfield Shipyard, Baltimore, one of the country's largest. Following completion in 8½ months—including buildings, electrical and mechanical installations, heavy foundation and structure work—the first of World War II's Liberty Ships was launched here.



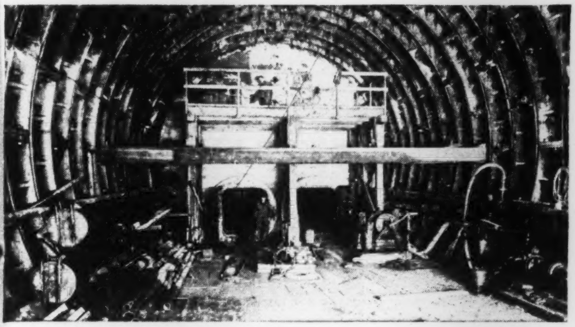
MARINE WORK. This Montgomery Island Dam, built by Booth & Flinn near Beaver, Pa., as part of the improvement of Ohio River navigation channels, created an upper pool 20 miles long, eliminated three of the river's lower-head locks and dams.



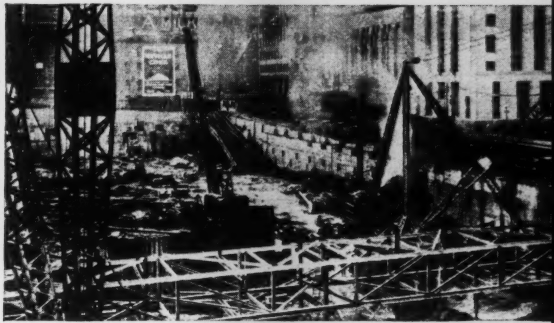
BRIDGES. The George Westinghouse Memorial Bridge, at East Pittsburgh, Pa., is only one of a wide variety of bridges constructed by Booth & Flinn in many parts of the country. Its 460-foot center span is the longest reinforced concrete arch in America.



INDUSTRIAL PLANT CONSTRUCTION. Part of the heavy foundation construction of the new Homestead Works of the Carnegie-Illinois Steel Corporation, involving 125,000 cubic yards of concrete for a new slabbing mill and 160-inch plate mill.



TUNNELS AND SHAFTS. In 1922 Booth & Flinn was awarded a $23,000,000 contract for building the Holland Tunnel—then the largest general contract ever let to a single firm in the United States. Many of the construction methods developed by Booth & Flinn during the building of these twin 8,330-foot tubes continue in use today.



FOUNDATIONS, CAISSONS, ETC. Foundations of the Federal Building and Post Office, Pittsburgh, extend through saturated sand and gravel to a depth of 100 feet, with part of the building's basement 30 feet deep, 15 feet below river level. Foundations for the 38-story Gulf Building were also constructed by Booth & Flinn by compressed air methods.

For almost three-quarters of a century, Booth & Flinn Company has been engaged in the successful completion of construction work on bridges, highways and grading operations, tunnels and underground lines, foundations, railroads, industrial and marine installations—and numerous other types of heavy and light construction.

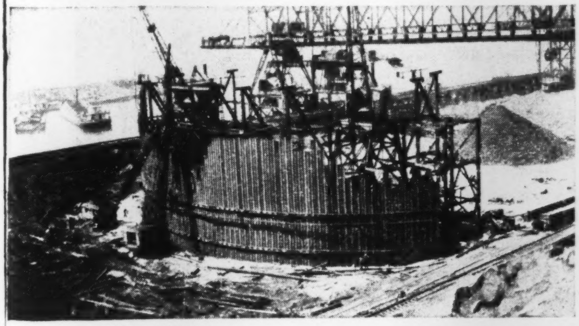
We are proud to be able to say that no job has been too large—or too small. Each project has benefited from the experience and techniques developed for those that have gone before, as well as from the practical training of on-the-job personnel.

To industrial engineers . . . corporation executives . . . railroad officials . . . public works engineers . . . architects . . . utility companies . . . and to others who have need of a general contractor, Booth & Flinn offers over 70 years of practical experience, trained personnel, efficient construction equipment and a sound financial position.

We invite your inquiries on any type of construction—at any time.

BOOTH & FLINN COMPANY

1876
GENERAL CONTRACTORS
PITTSBURGH 19, PENNA.
1949



PILE DRIVING. At one industrial plant, a portion of which is shown above, Booth & Flinn drove more than 14,000 tons of steel sheet piling to a depth of 90 to 100 feet. At another industrial plant 45,000 wood piles were driven, ranging in depth to 120 feet.

AQUEDUCTS, SEWERS, UNDERGROUND LINES. Thousands of miles of underground systems have been laid by the Company for sewers, water, oil and gas lines. More than 15 miles of the Catskill Aqueduct, carrying water to New York City, were constructed by Booth & Flinn.

"Welding permitted fewer supporting columns . . . gave more unobstructed floor area"

DUFFIN IRON COMPANY, FABRICATORS & BUILDERS
DE LEUW, CATHER CO., DESIGNERS

They added: "When designing this Coach Repair Shop for the Chicago, Rock Island and Pacific Railway Company, maximum unobstructed floor area was a prime requisite. Welded construction gave the freedom in architectural and structural design needed. Further, it reduces weight and cost of structural members without decreasing rigidity or structural strength."

For further details about welded construction write for "Manual of Design for Arc Welded Steel Structures" — a 300-page work that brings you information covering design, and engineering control of welding and related operations.

See this invaluable manual for yourself — mail us your check for $3.00, and we will send the book to you . . . look it over for ten days; if at the end of this period it does not completely live up to your expectations, return the book to us and we will return your money.

Write today! Address: Dept. 8091, Air Reduction, 60 East 42nd St., New York 17, N. Y. In Texas: Magnolia Airco Gas Products Co., Houston 1, Texas. On West Coast: Air Reduction Pacific Company, San Francisco 4, Calif. International Representatives: Airco Export Corporation, New York 18, N. Y.

AIRCO **AIR REDUCTION**

Offices in All Principal Cities

HEADQUARTERS FOR OXYGEN, ACETYLENE AND OTHER GASES . . . CARBIDE . . . GAS WELDING AND CUTTING APPARATUS AND SUPPLIES . . . ARC WELDERS, ELECTRODES AND ACCESSORIES

DOWNTIME SLASHERS–
YARDAGE MAKERS–
MONEY SAVERS...
Firestone
OFF-THE-HIGHWAY
TIRES
Firestone
ROCK GRIP EXCAVATOR
ROCK GRIP

IT TAKES a tire that's tougher than rock for quarrying, strip mining, and other severe operations, a tire that will take hold and GO . . . with heaping loads, right over the most treacherous terrain. The ONE tire that will do just that, day in and day out, is the Firestone Rock Grip.

Its thick, tough, "elephant-hide" tread is extremely resistant to cuts and snags. Those rugged power bars in the tread deliver plenty of traction, provide quiet rolling on pavement. The bodies of these tires are fortified to stand up, even under the most unmerciful beating. Their extra-strong, low-stretch, Gum-Dipped rayon cords prevent tire growth and preserve body strength for extra retreading.

Firestone Rock Grips will shorten your downtime, increase your yardage, and broaden your margin of profit.

GROUND GRIP

The maximum traction tire that keeps pulling for you anywhere on earth.

EARTH MOVER

The tire for free-rolling wheels that gives better flotation and longer life.

Listen to the Voice of Firestone every Monday evening over NBC and Americana over NBC Network Television Stations

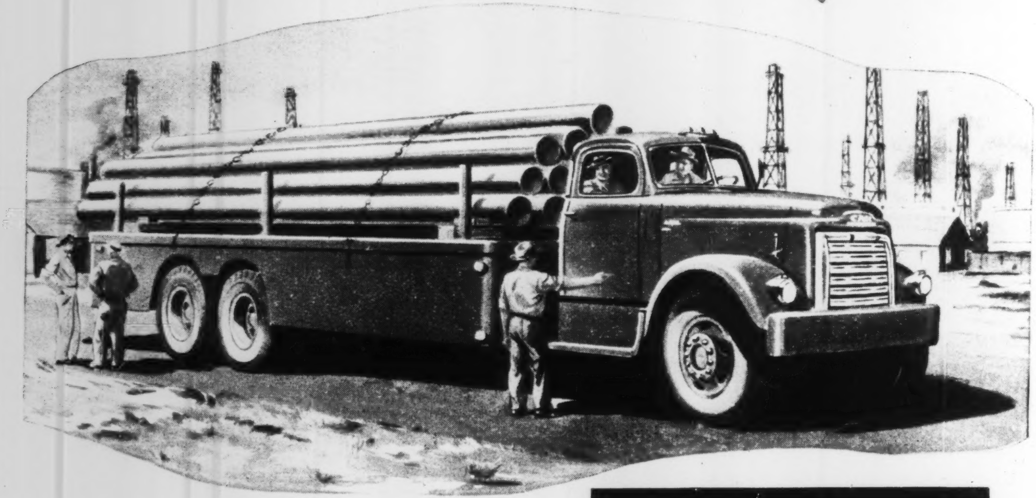
Copyright, 1949, The Firestone Tire & Rubber Co.

When you buy replacement tires or new equipment SPECIFY–

Firestone OFF-THE-HIGHWAY TIRES

All-New and...

Just as Rugged as They Look



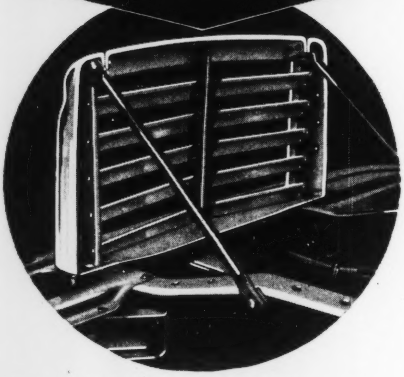
There's a new look in heavy duty trucks . . . all-new "H" line GMCs. These great new trucks, in weight ratings from 19,000 to more than 90,000 pounds, pace the entire heavy duty field in styling that adds to the prestige of your business. And they pace the field in design and engineering that give you better performance, lower operating costs, longer life.

Four new gasoline engines offer greatly increased power, in addition to traditional GMC extra value . . . famous four- and six-cylinder GM 2-cycle Diesels have higher compression for even greater agility and economy. New, stiffer, straight side rail frames, new wide-track axles, new broad-beam, extra comfort cabs . . . new features by the score make all-new GMC "H" models best for all heavy construction and oil field transport. Let your nearest GMC headquarters give you complete details.

GMC TRUCK & COACH DIVISION • GENERAL MOTORS CORPORATION

GMC
GASOLINE • DIESEL
TRUCKS

THE INDUSTRY'S ONLY
BUMPER-BUILT FRONT END



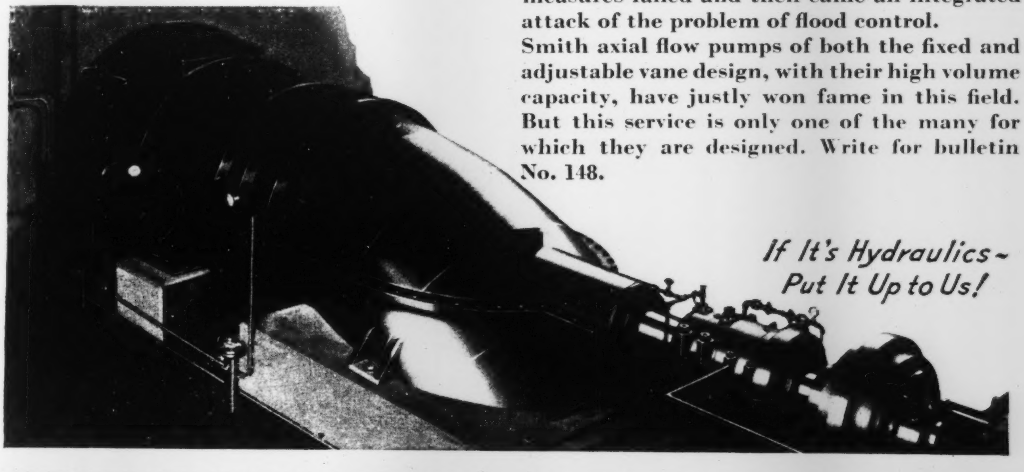
Typical of GMC "H" line ruggedness are angle-braced, frame-mounted radiator grilles with top and sides of spring steel bumper stock, heavy gauge fenders, wide, thick bumpers . . . for complete front end protection, axle to emblem.

old floods-
new pumps~

RISING, often, even in the dead of night, flood-water, one of man's first and ever-constant enemies has exacted its toll!

In the United States alone, millions of dollars in annual losses were expected. Makeshift measures failed and then came an integrated attack of the problem of flood control.

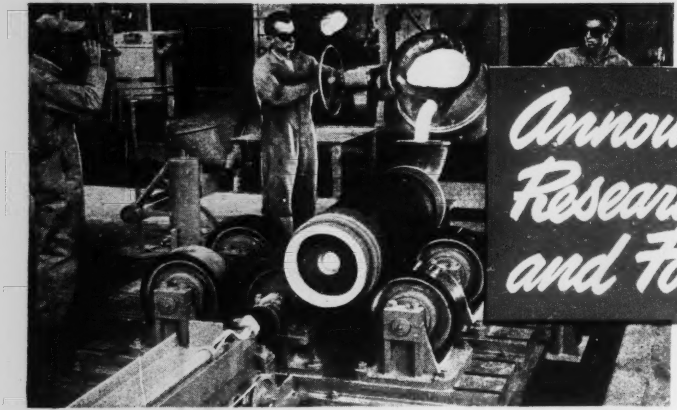
Smith axial flow pumps of both the fixed and adjustable vane design, with their high volume capacity, have justly won fame in this field. But this service is only one of the many for which they are designed. Write for bulletin No. 148.



If It's Hydraulics~
Put It Up to Us!

S. MORGAN SMITH Co.

YORK. PENNA. U.S.A.

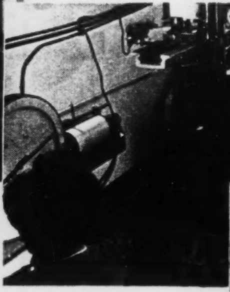


Announcing a New Research Laboratory and Foundry —

The Research Foundry is an integral part of the research laboratory and is housed in the same building. It is equipped with the most modern facilities for metallurgical research and development. Cut shows an experimental centrifugal casting operation.

To implement the expanded activities of our Research and Development Department in product and process research, we have built and equipped a new Research Laboratory and Foundry at Burlington where our General Offices and our Burlington plant are located. One of the largest and finest in the cast iron pressure pipe industry, its completion and recent dedication signalizes the 50th Anniversary of the founding of our Company.

The Metallographic Laboratory is devoted to the study of metal structure. Cut shows a Projection Microscope of the latest design. This precision instrument magnifies up to 4400 diameters.



Talbot Strip Tests—an acceptance test for centrifugally-cast pipe—are also conducted in the Physical Laboratory. A strip cut from pipe is under test and at left is the mechanized recorder which shows load and deflection.

The Chemical Laboratory is a service laboratory for research and development projects, and performs qualitative and quantitative analyses of a wide variety of materials. It also establishes standard analytical procedures for the laboratories at our several plants.

In the Physical Laboratory a 200,000 lb. universal testing machine of the most modern type is used for the Ring Crushing Test.

U. S. Pipe & Foundry Co.

GENERAL OFFICES: BURLINGTON, NEW JERSEY

UNIT CRANE & SHOVEL CORP.
UNIT
MILWAUKEE WISCONSIN
UNIT

Super Service

ON ALL TYPES OF JOBS!

½ and ¾ Yard
EXCAVATORS

CRANES UP TO
15 TONS

Every UNIT is FULLY CONVERTIBLE

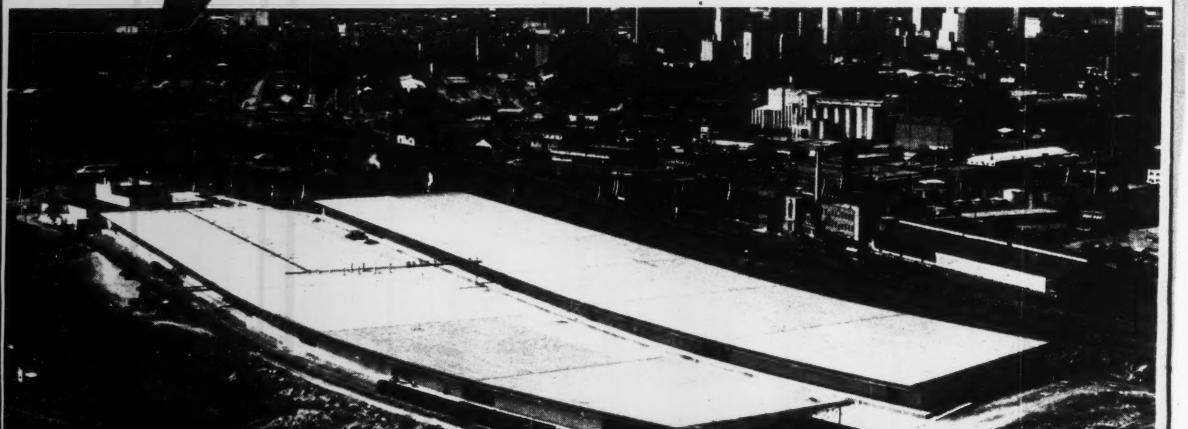
Regardless of whether your job calls for a shovel, clamshell, magnet, dragline, trenchoe, grapple or backfiller, a UNIT machine easily "fills the bill"! For UNIT is convertible to ANY attachment and gives an excellent account of itself on ALL types of service. The change from one attachment to the other can easily and quickly be made on the job, by any ordinary mechanic. UNIT exclusive features include: Automatic traction brakes . . . Disc type clutches . . . One-piece cast gear case and above all, UNIT's safety-promoting FULL VISION CAB.

You can tell it's a UNIT by the FULL VISION CAB. There's no other cab like it.

UNIT CRANE & SHOVEL CORP. 6315 WEST BURNHAM STREET
MILWAUKEE 14, WIS., U.S.A.

Pittsburgh Steeltex Helps Build a Greater America

Over 2,200,000 sq. ft. used to reduce costs, speed construction of world's largest refrigerated warehouse



The airview above shows the two buildings in the vast Alford Warehouse project. One building is for dry storage at 70° and the other for cold storage at temperatures ranging from 50° to —10°. M. C. Kleuser and Associates are the architects and engineers on the project.

Pittsburgh Steeltex

Pittsburgh Steeltex, a paper backed wire mesh, is being unrolled to form the reinforcing for the roof of the Alford Warehouse. Steeltex for Gunite was also used throughout for both inside and outside walls of the warehouse buildings. Steeltex for Plaster was used in office partitions.

The vision and daring that has built America to the greatest of Nations is exemplified in the vast 14,500,000 cu. ft. Alford Refrigerated Warehouse at Dallas, Texas. Here many practical materials and methods were used on a large scale to make possible a project that is typical of American ingenuity and progressive planning. Among the materials used was approximately 2 million sq. ft. of Pittsburgh Steeltex for Gunite plus 200,000 sq. ft. of Pittsburgh Steeltex for Floors and a large quantity of Steeltex for Plaster in office partitions.

Pittsburgh Steeltex is made of galvanized cold drawn steel wire and has a waterproofed paper backing laced to it by crimped stitch wires. It has been successfully used on many projects, large and small that have contributed to better living in America—made life more comfortable, safer for all.

Pittsburgh Steeltex for Gunite, Stucco, Plaster, Masonry Veneer and for Floors has proven to be the practical answer to many a cost problem.

For information on how you may use Steeltex on your jobs with economy see our Catalog in Sweet's or write to Department ENR, Pittsburgh Steel Products Company, Grant Building, Pittsburgh 30, Pennsylvania.

Pittsburgh Steeltex

For Floors, Stucco, Masonry Veneer or Plaster

Pittsburgh Steel Products Company

A subsidiary of Pittsburgh Steel Company

Move more yardage today
with the Scraper of tomorrow!

WOOLDRIDGE Model TC-142

14.2 cu. yds. struck, 17.5 cu. yds. heaped

BETTER!

PROVED!

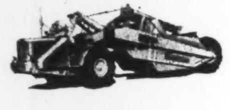
PROFITS!

Even faster loading is achieved by instant penetration of new 3-piece cutting edge. WIDER 65-inch apron opening and new curved ejector allow faster complete discharge of load. The rugged new TC-142 is built to "take" the heavier stresses imposed by today's more powerful tractors. Modern formed steel construction minimizes welding, increases structural strength. Higher yoke and ground clearance make maneuvering easy.

Proved Wooldridge advantages have been maintained. Original boiling bowl loading permits heaping volumes to surge freely into bowl. Pivot-tilt forced ejection dumps load faster with less cable strain. Rear-draft fulcrum leverage insures positive blade penetration. Cable is easily accessible, simply reeved over minimum of sheaves, all located away from load.

Job-proved, clean-lined, this IS the scraper of tomorrow—for greater production—for minimum operating cost—for highest profits TODAY! Contact your dealer or write for Bulletin TC-202 now for details. Other Wooldridge Scrapers from 7.5 to 27.5 cu. yd. heaped capacities.

WOOLDRIDGE MANUFACTURING CO.
Sunnyvale, California, U. S. A.



TERRA COBRA high-speed
self-propelled earthmovers
14.0 cu. yds. struck.
17.5 heaped.

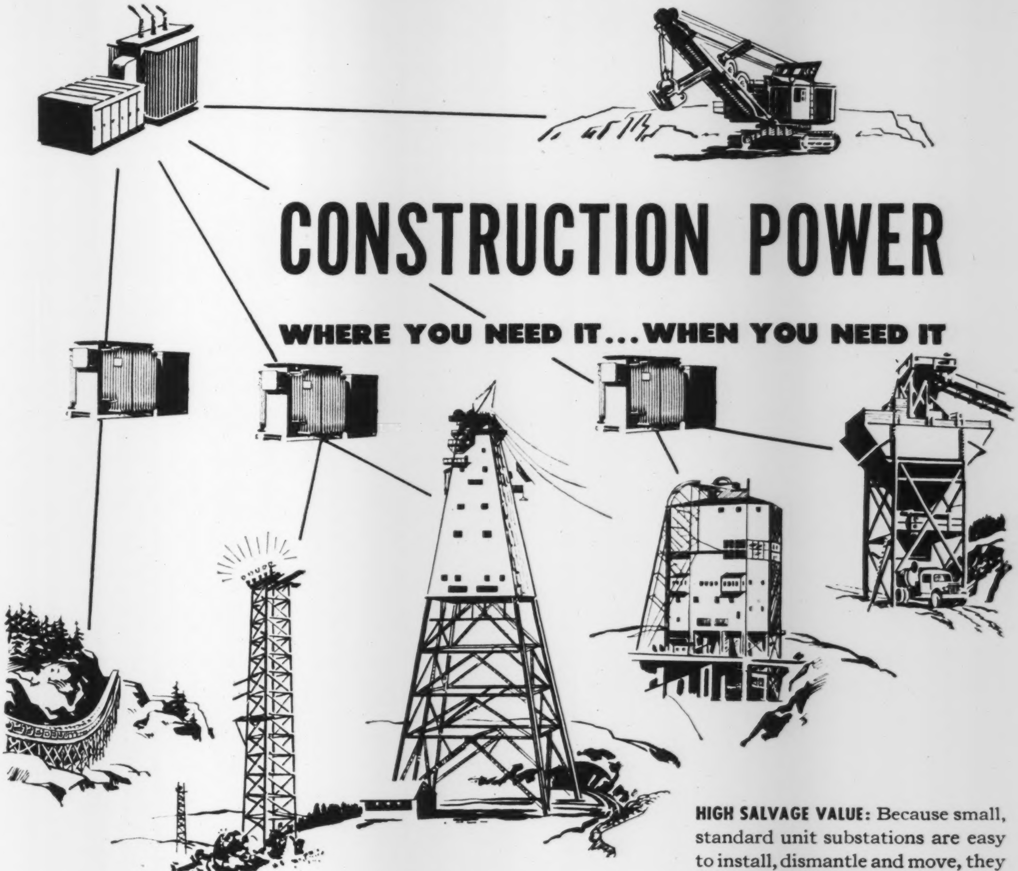
RIPPERS
BULLDOZERS
POWER CONTROL UNITS

WOOLDRIDGE EARTH MOVING EQUIPMENT

PROVED AND APPROVED FOR EVERY TYPE OF EARTH-MOVING JOB

CONSTRUCTION POWER

WHERE YOU NEED IT... WHEN YOU NEED IT



Easy to install, move or expand... G-E LOAD-CENTER DISTRIBUTION SYSTEMS offer reliable, flexible power for large construction projects

Here's how General Electric unit substations, used so successfully in strip mining, can be applied to large, long-term construction jobs . . . at a profit. Their high salvage value, portability and ease of installation will appeal to farsighted contractors. Power costs are reduced, too, by locating the substations near their loads, thereby keeping voltage high and cable short and light. Other advantages:

SAFE: Metal-clad unit substations combine transformers and circuit-breakers in one factory-assembled package; breakers protect your equipment from overload, the metal enclosure protects personnel from injury.

EASY SERVICING: Maintenance personnel work *on the ground* safely, quickly; no poles to climb.

ECONOMICAL: Evaluating the good voltage regulation, short-circuit protection and high service continuity provided, G-E load-center distribution systems give you more for your power-equipment dollar.

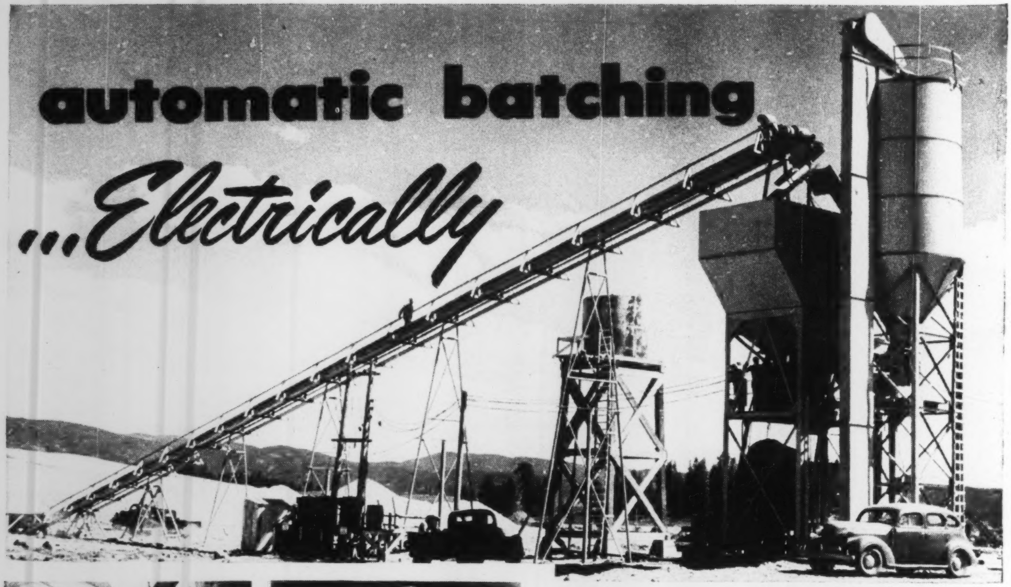
HIGH SALVAGE VALUE: Because small, standard unit substations are easy to install, dismantle and move, they may be moved to your later jobs at a substantial saving in man-hours.

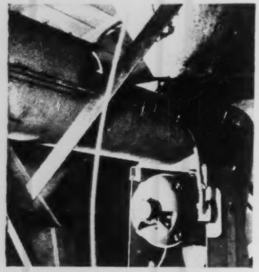
These are only a few of the advantages of modern load-center distribution systems for construction work. Let your G-E representative show you the entire picture; he will study your power requirements and help you select the best system for your particular needs. *Apparatus Department, General Electric Co., Schenectady 5, N. Y.*

ELECTRIFIED CONSTRUCTION
BETTER PRODUCT ★ LOWER COST

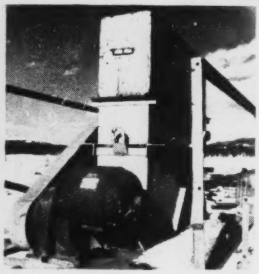
GENERAL ELECTRIC

automatic batching ...Electrically

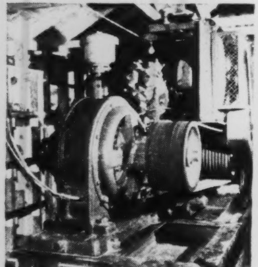




Cement from silo is fed to weigh batcher by worm screw, driven by G-E Tri-Clad motor.



Cement elevator drive is powered by G-E Tri-Clad motor.



G-E induction motor driving compressor which supplies air to batch plant and other equipment.

Bert Sandberg, Engineer for Granby Constructors, operates the G-E combination starter which controls the compressor motor.

G-E Motors and Control Speed Concrete Placing at Granby

Granby pumping plant, operating heart of the Bureau of Reclamation's Colorado Big Thompson project, is now under construction at an accelerated pace. To help maintain this pace, Granby Constructors are utilizing electric drive wherever possible as on this Noble batch plant . . . relying on General Electric components almost entirely.

Construction equipment driven by G-E motors and control, supplied from G-E Power-distribution systems, will help you meet schedules . . . at a profit! Apparatus Dept., General Electric Co., Schenectady, N. Y.

Ask him Today!

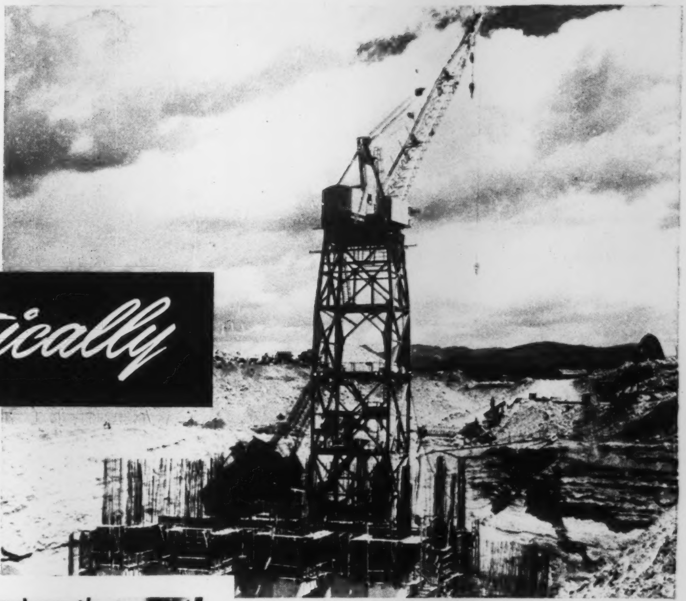
Whether you buy or build construction equipment, your G-E representative can show you how to do a better job at lower cost by complete electrification. Call, wire or write him now!

Electrified Construction
BETTER PRODUCT
LOWER COST

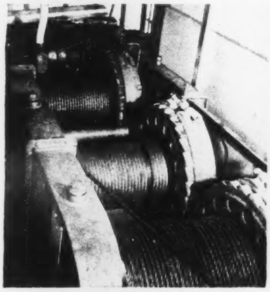
GENERAL ELECTRIC

swing and hoist

... Electrically



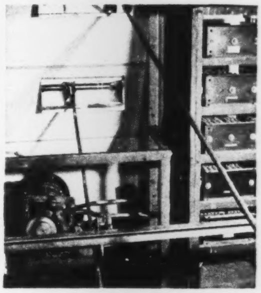
G-E equipped Colby crane at work on site of Granby Pumping Station



Hoist assembly consists of cable drums and General Electric 100-hp motor

Operator at controls of Colby crane, spotting loaded concrete buckets

Inspection and maintenance of the G-E control equipment is easy



Swing motor and resistor assembly are compact, yet readily accessible

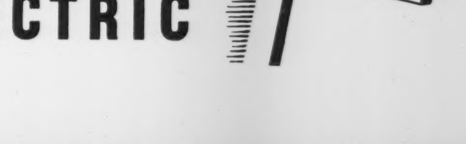
Colby Crane Helps Granby Constructors Shorten Schedule

Here's the "sky hook" that's accelerating concrete placing operations at Granby Pumping Station, heart of the Bureau of Reclamation's Colorado Big Thomson project. The crane is built by Colby Steel and Engineering Company of Seattle and embodies the latest and most efficient electric drive and safety devices.

Machinery manufacturers and contractors alike are realizing the time and money economies of *electrically* driven construction equipment. And by specifying General Electric they get the additional advantages of engineering assistance in application, installation and service wherever the job may be.

Ask him Today!

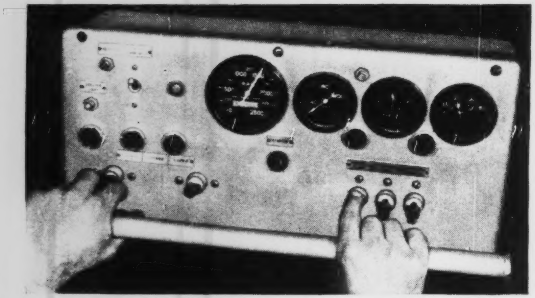
Whether you use or build construction equipment, your G-E representative can show you how to do a better job at lower cost by complete electrification. He will be glad to call on you at your convenience. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*



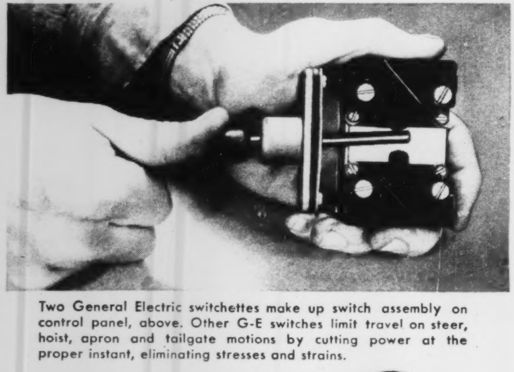
GENERAL ELECTRIC

maneuvering a monster... *Electrically*

New LeTourneau Scraper Moves 16-ton Loads at Touch of a Button



Control panel of LeTourneau's Model "C" Tournapull; a fingertip movement instantly applies power to motors which steer the vehicle, operate hoist, apron or tailgate.



Two General Electric switchettes make up switch assembly on control panel, above. Other G-E switches limit travel on steer, hoist, apron and tailgate motions by cutting power at the proper instant, eliminating stresses and strains.

The trend toward electrification of construction equipment has even invaded the mobile-tool market; witness the giant earth mover with electric power-steer and electrically operated hoist, apron and tailgate. Contractors using this new tool will move more yards per day at lower cost per yard because the electric drive offers fast, accurate, effortless control. This means instant response, quick reversal, increased operator comfort and efficiency. Gone are the multiple, clumsy manual controls and many mechanical linkages which slowed operations and increased maintenance costs.

Ask him Today!

Electric drive, which offers the maximum in reliability with minimum maintenance, helps contractors build more for less . . . faster. Whether you build or use construction tools, ask your General Electric representative to tell you about the inherent advantages of electric drive. ***Apparatus Department, General Electric Company, Schenectady, N. Y.***

Electrified Construction
BETTER PRODUCT
LOWER COST

GENERAL ELECTRIC

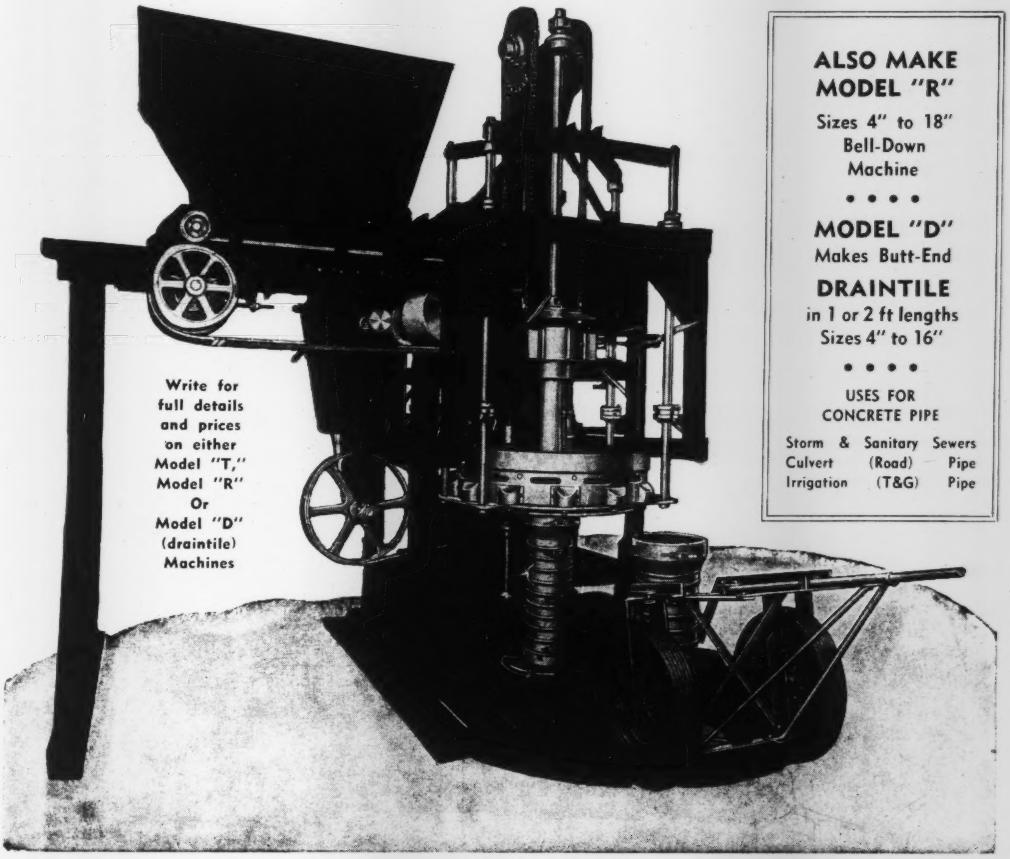
664-4

CONCRETE PIPE MACHINERY CO.

MODEL "T" BELL-UP "McCRACKEN" MACHINE

FOR MAKING PLAIN AND REINFORCED CONCRETE PIPE

Range of Sizes—4" to 36"—90% of the Market



ALSO MAKE MODEL "R"

Sizes 4" to 18"
Bell-Down
Machine

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MODEL "D"
Makes Butt-End

DRAINTILE
in 1 or 2 ft lengths
Sizes 4" to 16"

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USES FOR CONCRETE PIPE

Storm &	Sanitary	Sewers
Culvert	(Road)	Pipe
Irrigation	(T&G)	Pipe

Write for full details and prices on either Model "T," Model "R" Or Model "D" (draintile) Machines

PACKER-ROLLER-HEAD PROCESS

LEADS THE WAY TO MORE PROFITABLE PIPE BUSINESS

Eight-Hour Shifts Produce:

SEWER
Plain B & S Pipe

2400 feet	— sizes	4" to 10"
1750 "	— "	12" to 18"
1200 "	— "	21" to 24"

For Full Details Write to ↓

CULVERT "ROAD"
Reinforced T & G Pipe

1600 feet	— sizes	12" to 18"
1100 "	— "	21" to 24"
900 "	— "	30" to 36"

Concrete Pipe Machinery Co.

EXPORT OFFICE
121 Broad Street, New York (4), N. Y., U. S. A.

Cable Address: Macpipe

—MAIN OFFICE—
Sioux City (19), Iowa, U. S. A.

IF IT ISN'T ACCURATE IT ISN'T SIMPLEX

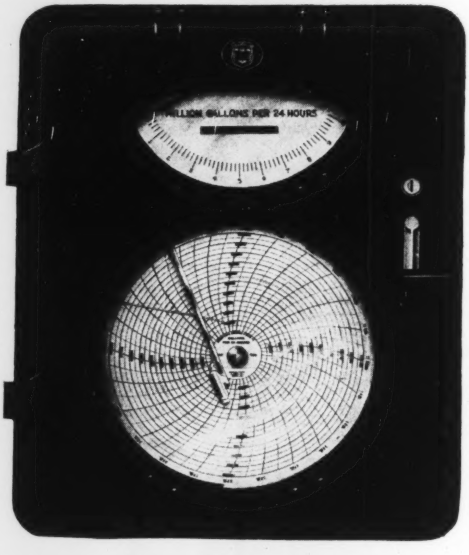
We of Simplex believe the discerning engineer requires accuracy above all other things in any instrument he purchases. If the word "Simplex" could be translated into modern language it could well mean accuracy, for that is the primary feature of all products bearing this name. While we are concerned with long life, continuous operation, and modern appearance, we nevertheless stress and stress again the most important point of all – accuracy. In presenting the type H meter, we confidently offer to the industry an instrument which fulfills this feature to an extremely gratifying degree.

NEW TYPE H METER

Most accurate yet developed within its flow range

ACCURATE within ± 2% at any point over flow ranges up to 10 to 1, the meter is designed for:

- Use with Venturi Tube, Flow Nozzle, or Orifice Plate.
- Measurement of hot or cold water, process liquors or gases.
- Outdoor or indoor mounting, using the same instrument for both conditions.
- Inclusion of three vital measuring elements—indicator, recorder, and totalizer.
- Wall bracket, instrument panel, or floor mounting as desired.
- Even spacing of the indicator dial and recording chart graduations for ease of reading at high or low flow rates.
- Testing in place at any time with an easily applied manometer test device.
- Change of differential pressure maximum by use of a different float without change of cylinder.
- Maximum differentials of 114" or 64" of water as desired.



Write for Bulletin No. 400 to
Simplex Valve & Meter Company, Dept. 9
6751 Upland Street, Philadelphia 42, Pa.

If it isn't ACCURATE it isn't SIMPLEX

SIMPLEX
VALVE AND METER COMPANY

GREATER EFFICIENCY AND ECONOMY

THE DORSEY

EARLE EQUIPMENT CO.
EARLE EQUIPMENT CO.

Select the DORSEY Low Bed Machinery Trailer with Confidence!

Model M 15-20-25 Tons

Model MT 35-40-50-60-75 Tons

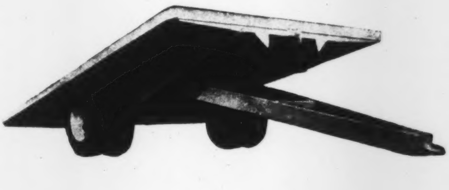
Model MK 10-15 Tons

Contractors and Engineers throughout the nation are selecting the Dorsey Low Bed Heavy Duty Semi or Full Trailers to move heavy equipment . . . to "Make the Heavy Jobs Light."

Dorsey Low Beds are available in four models — M — MK — MTS and MT — with capacities from 10 T to 75 T — a model for every need and state law load limit.

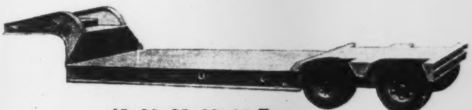
"Engineered for minimum weight . . . safe road performance . . . new low platform height . . . new hydraulic, air or vacuum brakes, all are features of advanced design that insure *low, dependable, operating economy.*"

DORSEY TILT-TO-LOAD TRAILERS



A-7 7,500 lb. A-15 15,000 lb. A-20 20,000 lb.

Model MTS



15-20-25-30-35 Tons

DORSEY TRAILERS

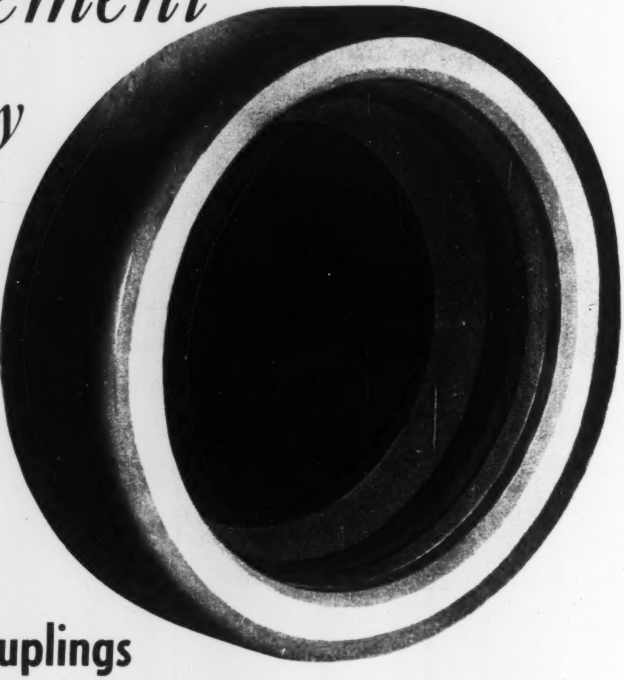
ELBA ALABAMA, U. S. A.

MODERN DESIGNED TRANSPORTATION

Announcement

Extraordinary

TO ENGINEERS



TYLOX

Flexible Rubber Couplings

For Vitrified Clay Pipe

Tylox Couplings give full floating, cushioned, multiple rubber sealing to vitrified clay pipe joints . . . industrial effluent lines . . . drainage, irrigation and siphon lines. Tylox provides a simple, efficient and fool-proof assembly, regardless of weather or trench conditions.

Tylox Vitrified Clay Pipe Joints are **leak proof** . . . self-locking . . . acid and alkali resistant, sewage and industrial waste resistant. Tylox Rubber Joints are flexible in angular and lengthwise movement.

Tylox Couplings are pre-assembled . . . cast at the plant . . . shipped complete and ready for coupling. Use of Tylox Couplings eliminates dimensional variation in sockets. Full contact of gasket surface with entering spigot is assured.

Phone, wire or write for complete information.

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PRESSURE TREATED **AMCRECO** CREOSOTED PRODUCTS

PROTECT THE DANGER LINE!

Here's enduring protection at the ground line . . . where the greatest danger exists. Amcreco Creosoted Products, made from selected timber chosen to withstand heavy, severe driving, are pressure treated by the Lowry Process, refined and improved by Amcreco research, to assure maximum strength. For every job, Amcreco's advanced treating techniques assure longer service life and low maintenance. Take advantage of Amcreco's experience on your next job . . . our engineers will gladly work with you.

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FRAMED BRIDGE TIMBERS

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ADZED AND BORED CROSS TIES

BRIDGE TIES

Pressure treated
by the
Lowry Process
for strength that lasts!

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Whatever the Job
Call on MANITOWOC

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SPEED PULLSHOVELS

18 TON TO 100 TON • 1 YARD TO 5 YARD

Top Performers on Any Job!

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Smooth precision work for leading erectors

to COAL STRIPPING
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EQUIPMENT AVAILABLE FOR THE DIFFICULT JOBS

- Independent Swing
- Hydraulic Torque Converter
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- Winch head
- Hi-lift shovel booms

See your
MANITOWOC DISTRIBUTOR
MANITOWOC ENGINEERING WORKS
MANITOWOC, WISCONSIN

A flange broken 50 years ago...

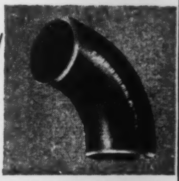
...led to one thing, to another, to another...

When Taylor Forge started up, way back, with spiral pipe it was our No. 1 item (still important). In those days cast iron flanges were largely used, and the troubles resulting from flange breakage were frequent and aggravating. The remedy for this major headache was found in the development of forged steel flanges; first for our own spiral pipe, later for our straight seam, and in fact any pipe; finally for general pressure vessel and industrial application.

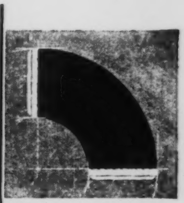
That put us definitely in the forging business some forty years ago and was the start of a long pioneering journey into the field of engineered piping problems. The expanding needs of industry multiplied the response for larger, heavier, stronger, and tougher flange and ring forgings to which we reacted with new, heavier, and numerous units of forge, press, and rolling equipment. It was equally necessary to pioneer design methods, not only for flanges and pipe application, but for other pressure vessel components as well—so that almost automatically we became, and remain, the world's largest manufacturer of forged (or forge-rolled) steel flanges, welding necks, manways and nozzles, etc., for *any* application.

Then came rapid strides in the art of welding which quickly cancelled out the crude, cut-fit-patch methods first attempted in pipe systems. Again we found it necessary to *engineer* the design of suitable components. Several years of research preceded the development of the *full,* engineered line of Taylor Forge welding fittings—the well-known WeldELL line. Examine the illustrations to the right, and note how many unique features combine good engineering with good sense and ultimate economy. The coupon below is the convenient means for getting more information about the fittings that have "Everything."

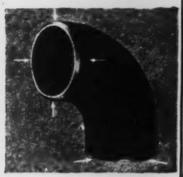
WeldELLS *have everything*



1. Forged and formed seamless throughout.



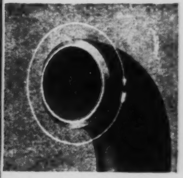
2. Sized end tangents on every fitting.



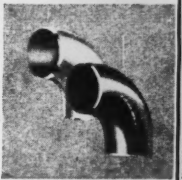
3. Precision quarter-marked ends that guide the work.

4. Engineered for full strength throughout.

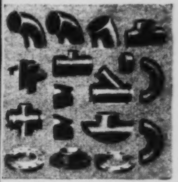
5. Markings on every fitting clear and complete.



6. Cleanly machined bevels and lands.



7. All materials: Carbon and alloy steels, corrosion resistant alloys.



8. The world's widest range of types, sizes and weights.

TF TAYLOR FORGE

TAYLOR FORGE & PIPE WORKS General Offices & Works: Chicago 90, Ill. (P.O. Box 485). Eastern Plant: Carnegie, Pa. Western Plant: Fontana, Calif. • District Offices—New York: 50 Church Street • Philadelphia: Broad Street Station Bldg. • Pittsburgh: First National Bank Bldg. • Chicago District Sales: 208 S. LaSalle Street • Houston: City National Bank Bldg. • Los Angeles: Subway Terminal Bldg.

Please send a copy of your new catalog 484 covering welding fittings and forged steel flanges.

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Position________________________________

Company________________________________

Street address____________________________

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614-0949 Mail to Taylor Forge & Pipe Works, P.O. Box 485, Chicago 90, Ill.

CLYDE *takes Pride* IN ITS 50 YEARS of SERVICE 1899...1949 TO THE CONSTRUCTION INDUSTRY!

From an obscure beginning as a small manufacturer of logging equipment and tools to an organization serving the construction industry the world around represents a record of achievement of which we are proud. Our pride is not based on the size of our physical plant, or the number of our personnel. Our satisfaction stems from the service rendered to the construction industry in the building of **quality** equipment engineered to reduce cost for progressive contractors . . . **help them earn more adequate compensation for skills that make a country strong.**

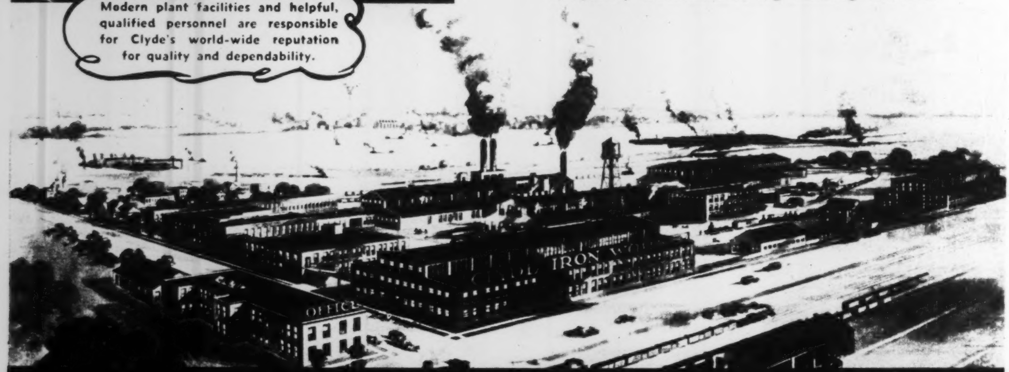
Clyde's sales and service organization is but an index of service rendered . . . service which is a source of pride to Clyde and a source of profit to the construction industry . . . an industry basic to our progress and well-being.

NORTHWESTERN MANUFACTURING CO.
LOGGING TOOLS, SLEIGHS and GENERAL FORGING.

1889 Plant and Personnel of Clyde as it was then known.

One of Clyde's many 'first' . . . the McGiffert log loader completely revolutionized log handling methods.

1949 Clyde Whirleys speed material handling and lower labor costs on this dam construction job.



Modern plant facilities and helpful, qualified personnel are responsible for Clyde's world-wide reputation for quality and dependability.

Hoists • Derricks • Whirleys • Builders Towers • Car Pullers • Handi-Cranes • Rollers

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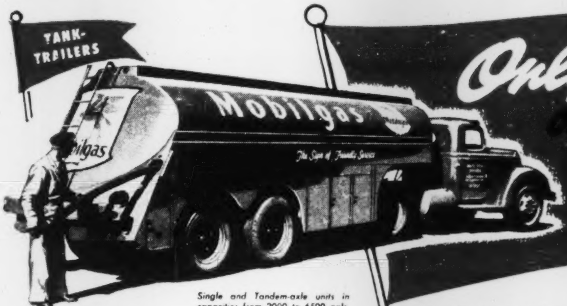
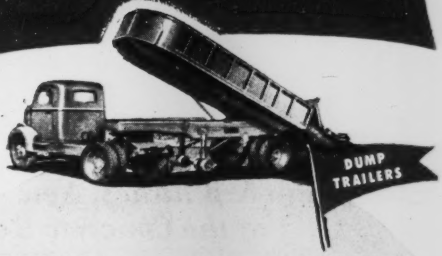
A SUBSIDIARY OF Barium STEEL CORPORATION Steelwright to the Nation

Only Fruehauf

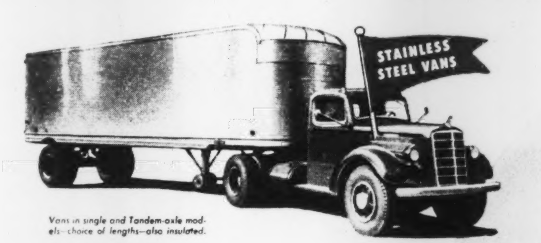
OFFERS YOU SUCH A WIDE VARIETY OF HAULING EQUIPMENT!



Single and Tandem-axle units in capacities from 2000 to 6500 gals.



Especially designed for hauling low-bulk high-weight products.



Vans in single and Tandem-axle models—choice of lengths—also insulated.

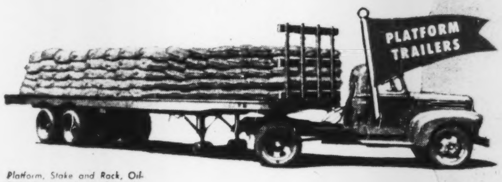
SHOWN here are only seven of the models in the Fruehauf line—a line which offers a Trailer or Truck Body for just about any load you can think of, either liquid or solid.

In the *standard* Trailer line alone there are seventeen *different* body types—and if you now use motor trucks, it is almost certain that one of them will cut your costs, perhaps as much as 60%.

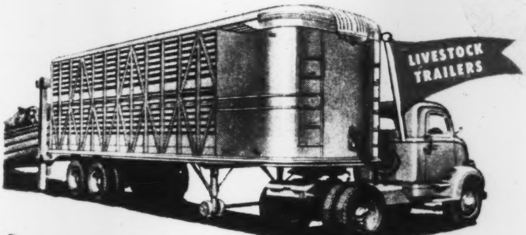
If a standard model isn't the answer, our engineers will gladly design a unit especially for you.

Just let us know what you haul and, without obligation, we'll send complete information on a Trailer to suit *your* needs.

●



Platform, Stake and Rack, Oil-Field Floats in choice of lengths.



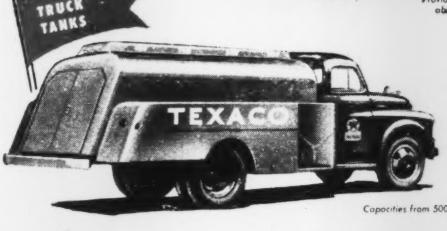
Provide perfect protection for stock. Available with single and tandem axles.

World's Largest Builders of Truck-Trailers

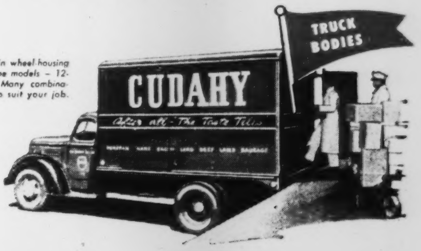
FRUEHAUF TRAILER COMPANY

Detroit 32 - In Canada: Weston, Ontario - Los Angeles 11

80 Factory Service Branches



Capacities from 500 to 3000 gallons!



All-Steel Bodies in wheel-housing and straight frame models — 12-14-16 ft. sizes. Many combinations — doors to suit your job.

Hear Harrison Wood in "This Changing World." Every Sunday over ABC. Consult Your Local Paper!

FIRST **IN TRUCK-TRAILER TRANSPORT!**

PLAIN HORSE SENSE
YOU CAN PULL FAR MORE THAN YOU CAN CARRY!

FRUEHAUF TRAILERS

"ENGINEERED TRANSPORTATION"

Award OF THE CONCRETE

"In recognition of a noteworthy contribution to the

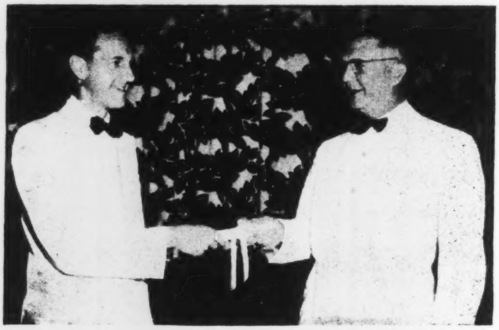
Ammann & Whitney, New York City, receives the 1949 Award of the Concrete Reinforcing Steel Institute

The Award was made to Ammann & Whitney in recognition of their noteworthy contribution to the advancement of reinforced concrete construction, by means of new concepts in the design of thin-shell reinforced concrete structures.

Both Mr. Whitney and Mr. Ammann have been well known within the engineering profession for many years. They formed their present partnership in 1946.

Mr. Charles S. Whitney is a graduate of Cornell University and holds a Masters Degree in Civil Engineering. Mr. Ammann is a graduate Civil Engineer of the Swiss Federal Polytechnic Institute of Zurich, Switzerland. Mr. Whitney has written many papers which have been published in various technical journals and has been engaged as Consulting or Designing Engineer for many structures, bridges, schools, industrial and commercial buildings and institutions. Mr. Ammann for many years was Chief Design Engineer and Chief Engineer of the New York Port Authority, Triborough Bridge and Tunnel Authority. In this connection he was identified with the design and construction of the George Washington Bridge crossing the Hudson River, Lincoln Tunnel, Triborough Bridge and the Bronx-Whitestone Bridge and many others.

As a firm, Ammann & Whitney designed the large American Airlines hangar and buildings in Chicago, which utilized a reinforced concrete roof shell; the Alabama Livestock Coliseum at Montgomery, Alabama, also involving the use of the thin-shell design; and miscellaneous bridges in Wisconsin and New York.



Mr. H. C. Turner, Jr. (left), President of the Turner Construction Company and Acting Chairman of the Award Committee, presents the 1949 Award of the Concrete Reinforcing Steel Institute to Mr. Charles S. Whitney, of Ammann & Whitney, at the 25th Anniversary Meeting of the Institute at The Greenbrier, White Sulphur Springs, West Virginia, on July 15th.

They have just completed the design of the Onondaga County War Memorial Auditorium at Syracuse, which involved the thin-shell design, and are currently making studies of the proposed New Jersey Turnpike. This firm not only has an outstanding record as designers, but has put into practice their contributions to the advancement of reinforced concrete.

The Award Committee of the Concrete Reinforcing Steel Institute is composed of one representative from each of the following organizations:

THE AMERICAN CONCRETE INSTITUTE　THE AMERICAN SOCIETY OF CIVIL ENGINEERS
THE ASSOCIATED GENERAL CONTRACTORS OF AMERICA

The personnel of the present Award Committee is:

Chairman, HENRY C. TURNER, JR., *President of the Turner Construction Co., New York, representing the Associated General Contractors of America.*

Member, CHESTER L. POST, *Consulting Engineer, Public Buildings Administration, Federal Works Agency, Washington, D. C., representing the American Concrete Institute.*

Member, FRANK E. RICHART, *Professor of Engineering Materials, Talbot Laboratory, University of Illinois, representing the American Society of Civil Engineers.*

REINFORCING STEEL INSTITUTE

advancement of reinforced concrete construction”

ANNUAL AWARD

The Annual Award of the Concrete Reinforcing Steel Institute is to be given for:

> *Research* contributing to the advancement of reinforced concrete. Noteworthy contributions to the *theory* of reinforced concrete *design*. Or improvements to reinforced concrete *construction practices.*

The Award consists of $500.00 cash, accompanied by a Certificate of Award.

Any person, firm or corporation, within the continental United States, shall be eligible to compete for and receive the Award.

The material submitted must be original and may be the result of either individual or joint effort.

Material entered in competition for the Award must *clearly* pertain to reinforced concrete *Research, Design Theory* or *Construction Practices.* It must be something comparatively new and a *noteworthy improvement* over present concepts, methods or practices. It is not intended that the Award be given for noteworthy examples of architectural beauty or novel uses of reinforced concrete. Award material will be judged solely from the viewpoint of its contribution to the overall improvement of reinforced concrete construction through research, design or construction practices.

The material submitted need not be in great detail, preferably brief, but in sufficient detail to enable the Award Committee to clearly understand and evaluate the worth of the contribution. The text matter should be in printed or typewritten form and, if need be, supplemented by drawings, photographs or other explanatory matter.

All material for consideration by the Award Committee must be submitted in quadruplicate. This material will not be returned.

The 1950 Award will be made at the Twenty-sixth Annual Meeting of the Institute at the Shamrock, Houston, Texas, during the week of March 20, 1950. The recipient of the Award will be invited to attend this meeting as the guest of the Institute. Anyone wishing to compete for the Award must have his material in the hands of the Secretary of the Committee not later than February 1, 1950. Any material received too late for consideration by the 1950 Award Committee will be held over and entered in competition for the 1951 Award.

Persons wishing additional information on the Award, or to submit material for consideration by the Award Committee, should communicate with Harry Delzell, Secretary to the Award Committee, c/o Concrete Reinforcing Steel Institute, 38 South Dearborn Street, Chicago 3, Illinois.

LINK-BELT SPEEDER *Shovel-Cranes*—PRODUCT OF 46 YEARS *of Continuous Improvement*

LINK-BELT SPEEDER
ROBERT HAWTHORNE
BUILDER

From its modest beginning in 1903, the history of Link-Belt Speeder is a record of continuous advancement. The pioneering spirit which has carried Link-Belt Speeder Shovel-Cranes into every corner of the globe has also produced advanced features in design and construction—contributing materially to their high standard of performance.*

Keeping every Link-Belt Speeder Shovel-Crane in tip-top operating condition is a primary concern of the Link-Belt Speeder Corporation and its nationwide distributor organization. In every principal city of the United States and Canada, and in foreign countries, a stock of parts and men specially trained in the servicing of Link-Belt Speeder products is in readiness to meet the needs of the user, wherever he may be located.

* Speed-o-Matic full hydraulic controls were introduced by Link-Belt Speeder on its $1\frac{1}{2}$ yard to 3 yard machines in 1935. The half-yard LS-51, latest addition to the Link-Belt Speeder line, is also Speed-o-Matic equipped, being the first half-yard Shovel-Crane to have full hydraulic controls.

There is a Link-Belt Speeder distributor near you prepared to aid you in selecting from the broad Link-Belt Speeder line of wheel and crawler-mounted Shovel-Cranes, the type and size best suited to your exact needs.

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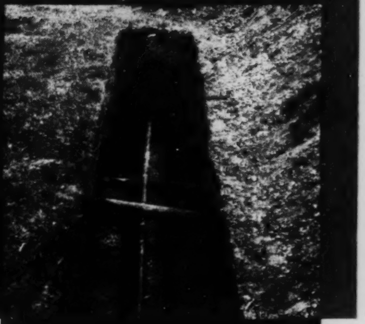
LINK-BELT SPEEDER CORPORATION, CEDAR RAPIDS, IOWA

BUILDERS OF THE MOST COMPLETE LINE OF SHOVELS • CRANES • DRAGLINES

The *Proof* of the PRODUCT is in its *Performance*

The Very First
RIC-WIL
Prefabricated
Insulated Pipe Units
Ever Installed Are
Still Giving Trouble-
Free Service After
14 Years of
Constant Use

Original condition of asphalt-coated conduit.



Asphalt-coated conduit still in perfect condition.

1949: **All lines functioning perfectly, trouble-free**

MINNEAPOLIS "No trouble... in constant use"
OMAHA "In good condition and is still serving in its original capacity"
DES MOINES "No trouble... in first class shape"

In 1935 the first Ric-wiL Insulated Pipe Units using asphalt-coated Hel-cor conduit as the outer protective housing were installed for a large products pipe line company, at Minneapolis, Omaha and Des Moines. Each of these steam lines consisted of 3" pipe insulated and enclosed in 8" conduit of standard 21' length Ric-wiL Units, with return lines laid outside the conduit.

In 1941 a check-up on these Ric-wiL Units under actual service conditions was made. Parts of the runs were excavated and a careful examination made of the conduit, fittings, etc. The Ric-wiL Units were in practically perfect condition, the same as they were when installed, with no perceptible deterioration or other damage.

In 1949 a further check-up of all three installations was made. This investigation, as indicated by the quotations from the reports given above, showed all the lines still in constant use, functioning satisfactorily and trouble-free.

In the years since this original installation, in thousands of central heating and industrial processing projects, Ric-wiL Insulated Pipe Units, constantly improved by engineering research and development, **have continued to prove, through performance, their right to unchallenged leadership in this field.**

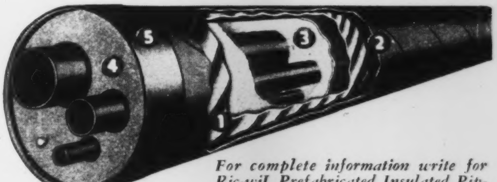
① **HOUSING of strong, shock-proof 16 gauge hot-dip galvanized Hel-cor conduit, spirally corrugated. Inside bonderized and coated with baked phenolic resin for additional protection.**

② **HIGH TEMPERATURE asphalt coatings reinforced with tension wrapping of asphalt-saturated asbestos felt.**

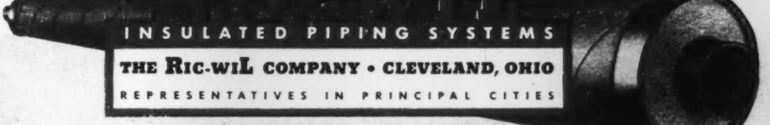
③ **INSULATION of high thermal efficiency—any required type or thickness.**

④ **PRESEAL RING of steam-cured insulating cement protects units during shipping and installation.**

⑤ **HEAVY IRON COLLAR provides a firm foundation in making full-welded watertight field joints.**



For complete information write for Ric-wiL Prefabricated Insulated Piping Systems Catalog 480-4. Address: The Ric-wiL Company, Dept. S-12.

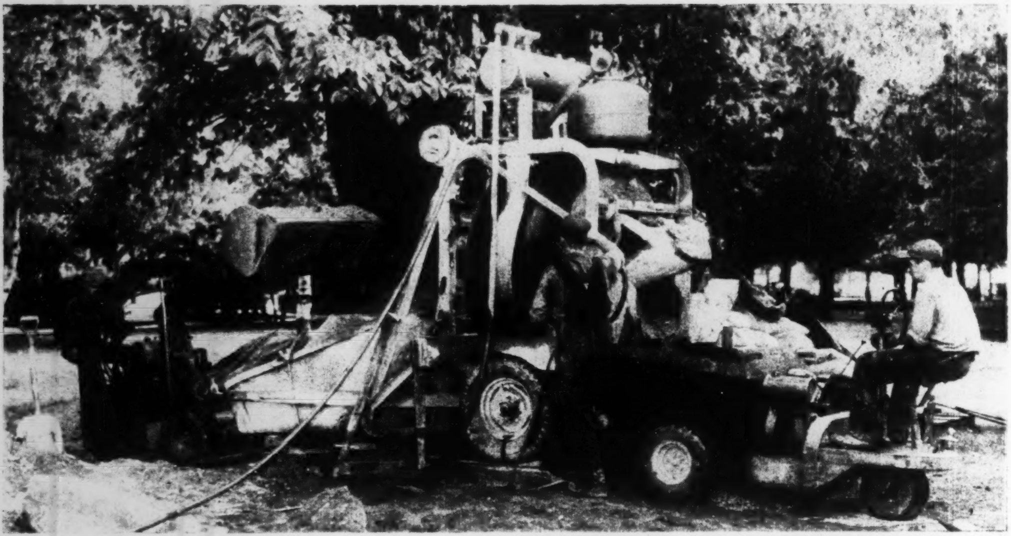


RIC-WIL

INSULATED PIPING SYSTEMS

THE RIC-WIL COMPANY • CLEVELAND, OHIO

REPRESENTATIVES IN PRINCIPAL CITIES



Getman Front End Loader is loading mixer skip and standard Scoot-Crete is taking finished concrete from output side of mixer, for delivery to the forms.

Two Leaders

Getman Hydraulic Front End Loader and Scoot-Crete

SCOOT-CRETE FEATURES

★ **Carries 1-Ton Load.** A 2,000-pound cargo is normal for the Scoot-Crete. When hauling concrete, this means running more mixer loads per day.

★ **Easily Maneuvered.** Because the Scoot-Crete is steered through worm and gear mechanism, jackknifing and wheel-shock are eliminated. Scoot-Crete will turn on a dime.

★ **4 Speeds Forward, 1 Reverse.** Plenty of power is available for grades of tough going and plenty of speed—15 miles per hour—for straightaways.

★ **Big Pneumatic Tires.** The Scoot-Crete runs anywhere, even on loose sand, without special roads or runways.

★ **Low Maintenance.** Rugged but simple construction with few moving parts keeps operating and maintenance cost at a minimum.

★ **7.5 H.P. Gasoline Engine.** Power is furnished by a 7.5 H.P. air-cooled engine, with double V-belt drive to 4-speed transmission.

GETMAN HYDRAULIC FRONT END LOADER FEATURES

★ **Rugged Construction.** Built rugged for any job of re-handling most materials.

★ **Maximum Maneuverability.** It has maneuverability and turns in a 6-ft. radius.

★ **Big Pneumatic Tires.** Has large tires on all wheels for flotation and traction.

★ **Complete Hydraulic Control.** Has complete hydraulic control with position bucket positioning at all heights.

★ **Speed up to 17 miles per hour.**

★ **Bucket Capacity—8 cubic feet.**

Complete Information Obtainable on Request

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Manufacturing Division

South Haven, Michigan, U. S. A.

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1929—1949

F. H. McGRAW

AND COMPANY

* . . . and going strong. Since it was founded 20 years ago, F. H. McGRAW & COMPANY has completed over $400,000,000 worth of engineering and construction work. McGRAW projects have included nearly every phase of construction — industrial plants, airports, highways, hospitals, office buildings, multi-family housing developments, sewage treatment plants, steel and paper mills, theaters, and even a race track. No job is too big or too small; no job too tough.

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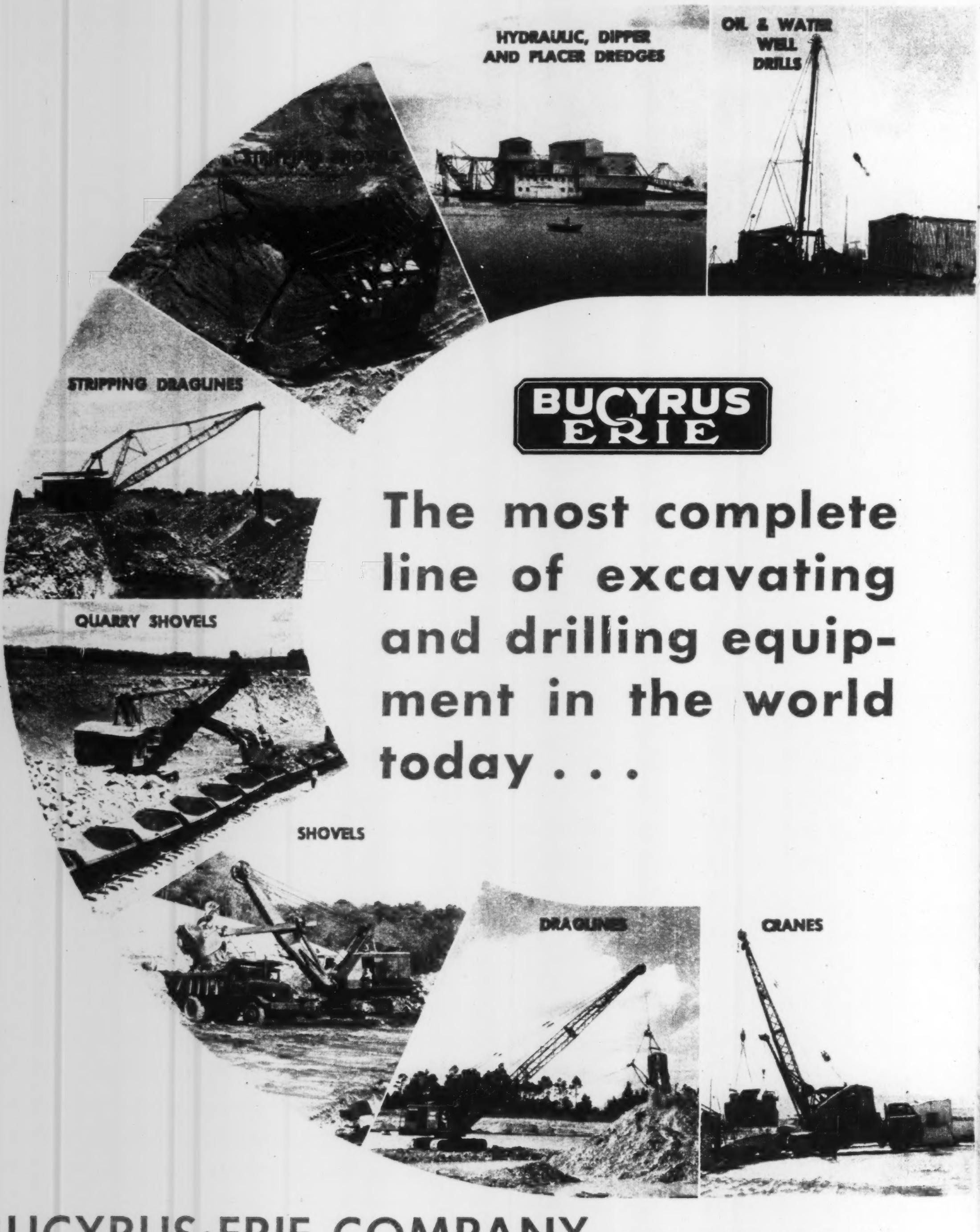
HYDRAULIC, DIPPER AND PLACER DREDGES
OIL & WATER WELL DRILLS
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BUCYRUS ERIE

The most complete line of excavating and drilling equipment in the world today . . .

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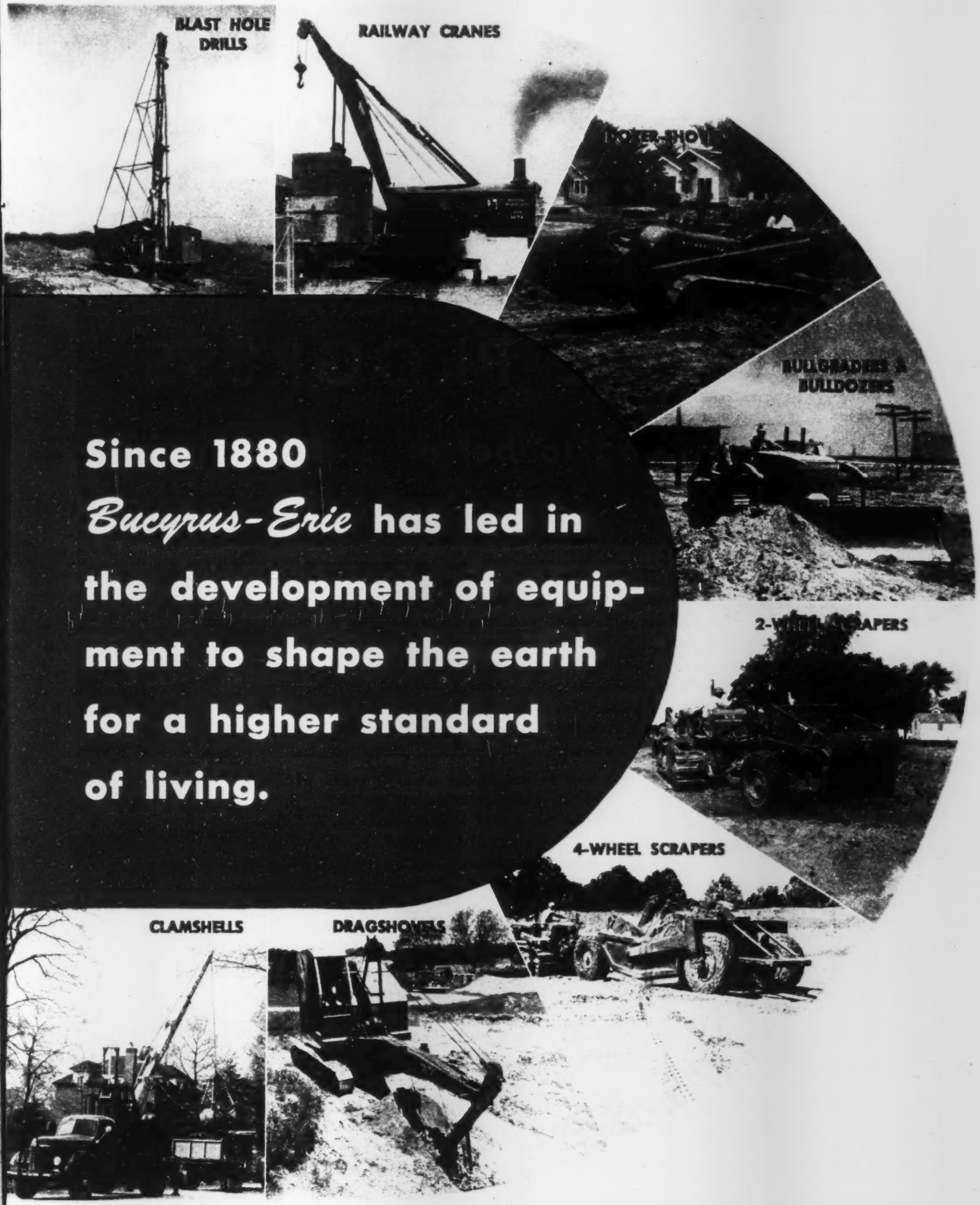
BLAST HOLE DRILLS
RAILWAY CRANES
DOZER-SHOVELS
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2-WHEEL SCRAPERS
4-WHEEL SCRAPERS
CLAMSHELLS
DRAGSHOVELS

Since 1880 *Bucyrus-Erie* has led in the development of equipment to shape the earth for a higher standard of living.

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CONCRETE PROGRESS
Contributing to better building

SINCE ITS ORIGIN IN 1892, the Medusa Portland Cement Company has made several noteworthy contributions to better building. Not content with manufacturing standard gray portland cement exclusively, the Medusa laboratories in its early years worked on such problems as the need for a white cement, for exterior treatments and Terrazzo; a waterproofed cement, that would produce a concrete or stucco impregnable to water; and a cement paint, for decorating and weather-proofing concrete, stucco and masonry surfaces.

Each of these problems was solved in the ensuing years. Medusa brought out the first White Portland Cement in 1907. A few years later, the industry was presented with a Waterproofed Gray. And still later, with Medusa Portland Cement Paint. In addition to these, BrikseT and StoneseT mortar Cements were developed. Still later, Medusa "Medco" High Early Strength and Medusa Air-Entraining Cements were placed on the market. Today, Medusa supplies the building industry with eight special cements best suited for special jobs. As Medusa looks forward to another "57 Years of Concrete Progress", our organization continues to concentrate every effort to produce better cements for better building.

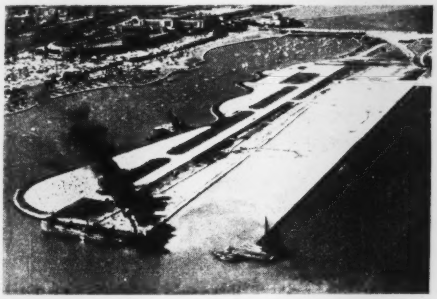
MEDUSA PORTLAND CEMENT COMPANY
1001-3 Midland Building • • Cleveland 15, Ohio

MEDUSA GRAY PORTLAND CEMENT • MEDUSA WATERPROOFED GRAY PORTLAND CEMENT • MEDUSA WHITE PORTLAND CEMENT • MEDUSA WATERPROOFED WHITE PORTLAND CEMENT • MEDUSA "MEDCO" HIGH EARLY STRENGTH CEMENT • MEDUSA AIR-ENTRAINING CEMENT • MEDUSA "BRIKSET" CEMENT • MEDUSA "STONESET" CEMENT • MEDUSA WHITE TILE GROUT CEMENT • MEDUSA PORTLAND CEMENT PAINT • MEDUSA RUBBER BASE COATING • MEDUSA WATERPROOFING PASTE AND POWDER

EIGHT CEMENT PLANTS . . . THREE WAREHOUSES

60 YEARS OF SUCCESSFUL RESULTS *with such clients as*

U. S. GOVERNMENTAL AGENCIES — MUNICIPALITIES — UTILITIES — RAILROADS — STEEL AND OIL COMPANIES — ALL TYPES OF INDUSTRIAL FIRMS



Northerly Island Air Port, Chicago

- Our marine work continues to be conducted in the Great Lakes, Atlantic Seaboard, Gulf of Mexico, Mississippi River and its tributaries. In addition we have done and are immediately available for Flood Control and Bridge Construction in any part of the country.

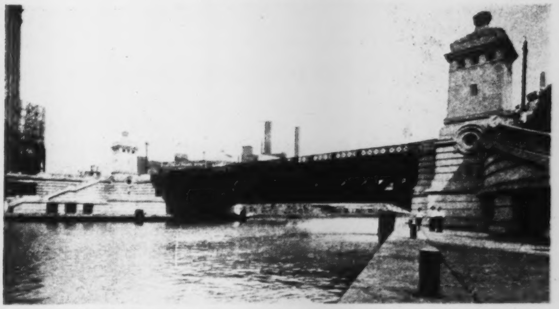
The list below gives you an idea of the extent of our past activities. We are geared to assume any of this work at any time. The pictures illustrate our diversification of work.

- Dredging (Dipper, Hydraulic, and Clam Shell)
- Submarine Rock Removal
- Docks
- Land Reclamation
- Pile Driving (all types)
- Foundations (Pile and Concrete)
- Bridges
- Piers
- Breakwaters
- Shore Protections
- Tunnels
- Pneumatic and Submarine Work and Foundations
- Oil Field Operations
- Flood Control

CONSULTATION INVITED

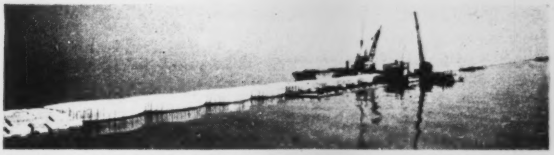
MacArthur Lock, Sault St. Marie, Mich.

Dredging and Filling for Buffalo-Niagara Corp., Buffalo, N. Y.



Michigan Ave. Bridge, Chicago—Sub & Superstructures and All Approaches

Rock Removal, Black Rock Channel, Buffalo, N. Y.



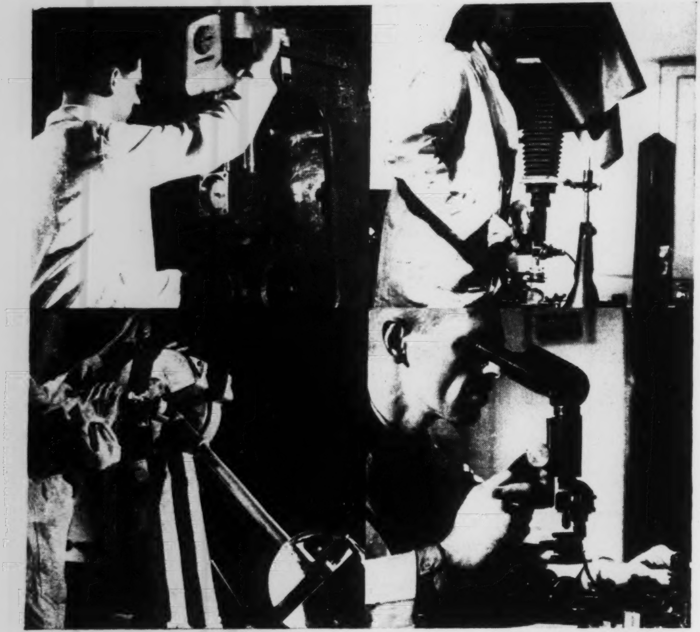
2520 ft. of breakwater constructed for Carnegie-Illinois Steel Corp. at Gary, Ind.

GREAT LAKES DREDGE & DOCK COMPANY

RIVER AND HARBOR IMPROVEMENTS

General Offices . . . Chicago 3, Ill.

BUFFALO 2, N. Y. • CLEVELAND 14, OHIO • MILWAUKEE 3, WIS. • NEW YORK 4, N. Y. • NEW ORLEANS 12, LA.



Raw material control means better Tube-Turn welding fittings

What's a piece of steel made of?

THE quality of a finished product is largely dependent on the quality of the raw material from which it is made. That's why Tube Turns' laboratory technicians thoroughly test every lot of seamless steel tubing received in the Tube Turns, Inc. plant.

Answers to that important question —*What's a piece of steel made of?*— are determined in two ways. First, by chemical tests that disclose the exact percentage of the various elements present in the steel. And, second, by physical tests to determine the steel's tensile strength, yield strength, and elongation. Unless the steel measures up in all respects, the entire lot is rejected.

At the end of these tests, not only is the chemical composition of the steel known, but an accurate appraisal of its metallurgical and physical characteristics has been made. And these facts are filed by the laboratory control number rolled into each fitting to identify it permanently with the lot of steel from which it was made.

This rigid control over raw material is your assurance of basic quality in the Tube-Turn welding fittings you buy. Modern equipment in the hands of skilled technicians permit only the best steel to be used for the manufacture of Tube-Turn products.

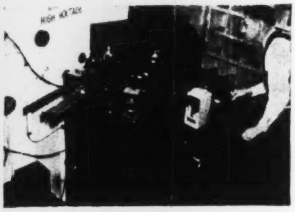
Remember, you can always bank on good service in good connections every time you specify "Tube-Turn."

TUBE TURNS, INC.

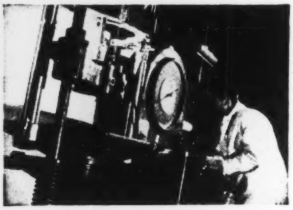
230 East Broadway, Dept. J, Louisville 1, Kentucky

District Offices at New York, Philadelphia, Pittsburgh, Chicago, Houston, Tulsa, San Francisco, Los Angeles

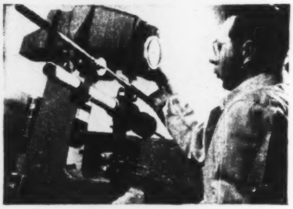
TUBE-TURN
TRADE MARK
tt
WELDING FITTINGS AND FLANGES



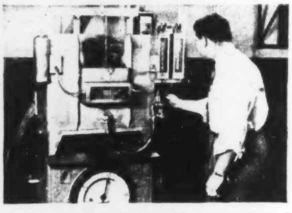
Foolproof chemical analysis of steel is made quickly and accurately on this Spectroscope, typical of the modern equipment used by Tube Turns, Inc. in the control of raw material.



Tensile strength of all seamless steel tubing is accurately measured on this machine, capable of exerting a force of 6,000 pounds. Yield strength and ductility are also checked here.



Periodic checks on the hardness of the steel are made with this Rockwell instrument to determine the strength, ductility, and machinability of the material. Brinell equipment is also used to check hardness.

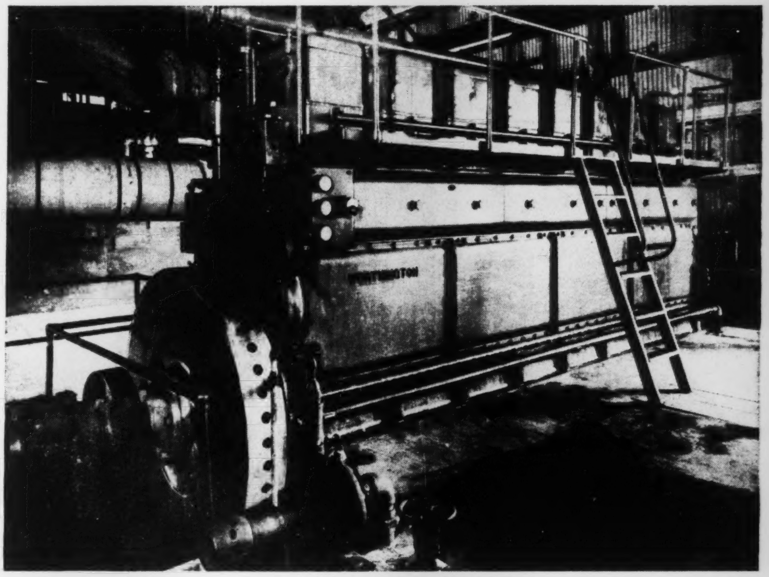


Advance indication of what will happen to the steel during processing is determined with this electric furnace, one of a battery. Heat treatment to which the material will be subjected is duplicated here.

NEWS

FROM THE
PUBLIC WORKS
FRONT

AS
REPORTED
BY
THE
DEVELOPMENT
ENGINEERS,
FIELD
SERVICE
REPRESENTATIVES
AND
CUSTOMERS
OF
WORTHINGTON



Worthington Gas-Diesel DDPG-8

Gas Diesel Cuts Fuel Costs 50%

The Hunter Station of Acadia Vermillion Rice Irrigating Company, Inc., located at Milton, Louisiana, provides rice growing farmers with water. The pumping capacity of this plant is about 350,000 gpm. The plant consists of two parts with the older part housing the steam engines.

Three Worthington Diesel engines, connected directly with 48 in. MA-1, Mix-Flo centrifugal pumps, were installed in the modern part of this plant. The first, a DD-8, was installed in 1939 . . . the second (same type) in 1942 . . . a gas Diesel DDPG-8 was put in operation in 1948.

Mr. J. W. Embry is in charge of field operations at this station. He states that he is very well satisfied with the performance of these Worthington Diesels.

According to some figures he worked up on a 24 hour schedule for fuel consumption cost per unit, Mr. Embry made this comparison:

"Steam engine No. 6 at 76 rpm in 24 hours pumps 86,400,000 gallons at a cost of $62.10 gas fuel.

"The gas Diesel at 325 rpm in 24 hours pumps 96,408,000 gallons at an approximate cost of $30.00 gas fuel plus about 4% Diesel fuel."

Worthington Helps in Los Angeles $41,000,000 Hyperion Project

The $41,000,000 sewage disposal project now under construction to give Los Angeles one of the country's most modern sewage treatment systems, will include nine Worthington 1688 hp dual-fuel 8-cylinder engines, to be installed in the power and blower building.

Five of these engines will drive Electric Machinery Co. generators rated at 1189 kw to supply the power for the operation of the sewage treatment plant including motor-driven auxiliary equipment. The engines and generators will be direct-connected and will operate at 360 rpm.

The four remaining engines will drive centrifugal compressors used for supplying air to the aeration tanks. Each compressor is rated at 40,800 cfm of air from an inlet pressure of minus 3 in. of water to a discharge pressure of 7.75 psi. The centrifugal compressors will be driven by the 360 rpm engines through step-up gears to a compressor speed of 3400 rpm.

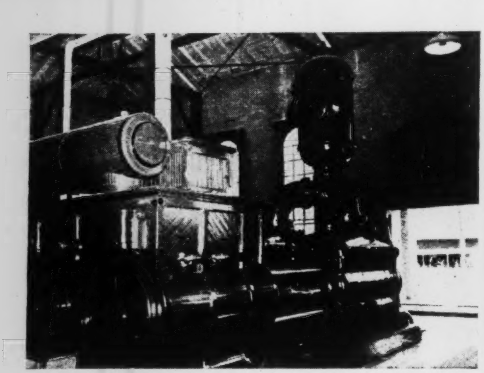
The exhaust and jacket water heat from all nine engines will be recovered and used to heat the sludge digesters.

Three Worthington 30" x 12" type DC horizontal duplex vacuum pumps will be installed in the filter and dryer building. These vacuum pumps are to produce the vacuum in the vacuum filters, for sludge filtration, and each will have a capacity of 4705 cfm and will be driven by 150 hp 240 rpm engine-type synchronous motor.

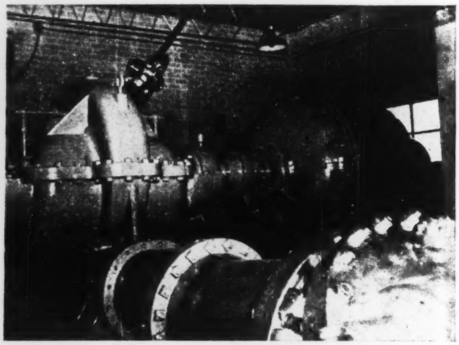
9-26

WORTHINGTON PUMP AND MACHINERY CORPORATION, HARRISON, N. J.

NEWS from the public works front



Pump installed by a company incorporated by Worthington for Galveston, Texas.



Worthington 20 LA-3 pump and 800 hp G. E. motor at the Fairwood Pump Station in Galveston, Texas.

After 61 Years, Still in Good Condition

In 1888, the City of Galveston, Texas installed 2 modern horizontal compound Duplex Double Acting Pumps in a new pumping station. The pumps were manufactured by a company incorporated into Worthington in 1916.

The large pump is reported to have been rated at 4,000,000 gallons per day at 28 strokes per minute at 60 lb pressure. On Sept. 8, 1900, the City of Galveston suffered a devastating hurricane which resulted in the complete wreckage of the City's main Pumping Plant. Following the storm, the main Pumping Station was rebuilt and the largest of these two pumps was placed in primary distribution pumping service. This pump carried the main load until 1912 when another horizontal steam unit was installed to supplement it. In 1923, it was placed in a standby condition.

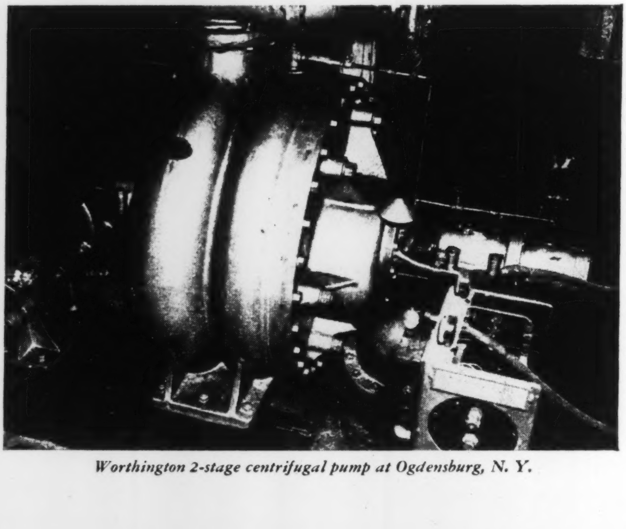
Galveston has now added a 20 LA-3 Worthington Centrifugal driven by 800 hp G.E. Synchronous motor to meet the needs of its growing population.

No Repairs in 37 Years

A Worthington two-stage centrifugal pump that went into operation in 1912 at the Oswegatchie Pumping Station, Ogdensburg, N. Y., has been operating almost continually ever since without one single repair being made on it.

The pump, which is driven from a shaft operated by water power, can pump five million gallons in 24 hours against a 50 foot head, and is idle only when low water or ice conditions prevail. A friction clutch permits disengaging the pump from the drive.

The average daily consumption is 2,500,000 to 3,500,000 gallons.



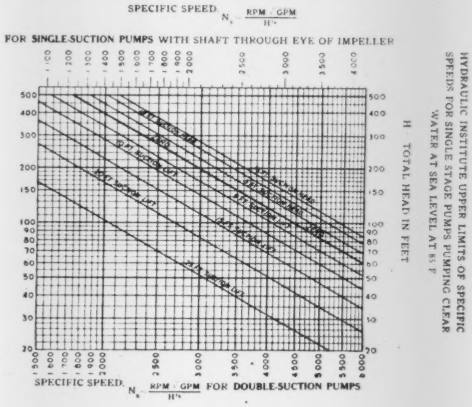
Worthington 2-stage centrifugal pump at Ogdensburg, N. Y.

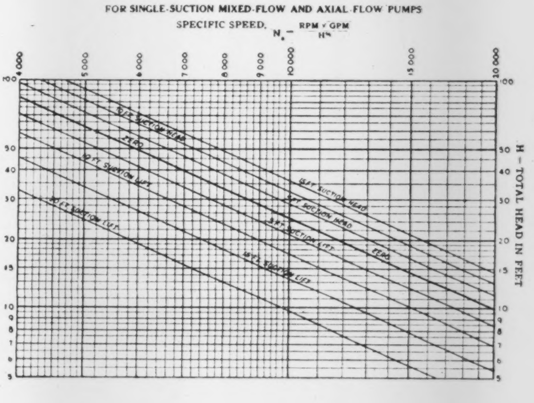
Worthington Pump and Machinery Corporation
Harrison, N. J.

NEWS

Engineer's Notebook

How Helpful to Centrifugal Pump Users Are the H. I. Specific Speed Limit Charts?





In the United States the basic definition of "specific speed" is the speed in revolutions per minute at which a theoretical and geometrically similar pump would have to run if proportioned to deliver 1 gpm against 1 foot total head at its best efficiency. *It is therefore an index of the pump type using the capacity and head obtained at the maximum efficiency point.*

The specific speed of a pump should be considered as a type number rather than the actual rotative speed of a 1 gpm 1 foot total head model pump, because in most cases such a model pump, if made, would be too small to be hydraulically similar.

The formula for determining specific speed is

$$N_s = \frac{n \quad Q}{H^{3/4}}$$

where N_s = specific speed
Q = gpm at speed N and head H
n = rotative speed in rpm
H = total head per stage in feet

The normal range in specific speed encountered in single suction impeller designs is from 500 to 15,000 and 700 to 6,000 in double suction impeller designs. Basically, the lower the specific speed type, the higher the head per stage that can be developed by the pump.

For a given total head and suction lift condition, it has been found from experience that the specific speed of a pump should be below a certain value for successful operation. The Hydraulic Institute has issued a series of charts, the so-called Specific Speed Limit Charts, each applying to a given type of centrifugal pump, showing the maximum recommended specific speed for a combination of total head and suction conditions. It must be realized in using these charts that pumps built for the limit allowed are not necessarily the best design for the intended service. It also must be realized that the individual pump design limits its application for both maximum head and for suction condition limitations. For example, for the 200 feet total head and 15 feet suction lift, the maximum recommended specific speed for a double-suction single-stage pump is 2130. It does not follow that all double-suction single-stage pumps of 2130 specific speed type are suitable for operation at speeds which will cause them to develop 200 ft total head (at maximum efficiency) . . . nor that the pump, if suitable for operation at 200 ft total head, is suitable for operation with 15 ft suction lift . . . nor that a pump of this type operating against 200 ft total head would on test only be found capable of operating on 15 ft maximum suction lift. These Charts are intended to indicate only the maximum rotative speed for which a centrifugal pump can be designed, according to the latest experience at the time it was made, with assurance of a reasonable and proper operation for the combination of operating conditions.

There are some records of successful application of centrifugal pumps exceeding the Limit Charts. As more data is obtained on such installations, it may be found that the present limits are too conservative. The policy of the various pump manufacturers of offering pumps that are within the Hydraulic Institute recommendations gives purchasers assurance that a trouble-free application should result.

LAPLANT-CHOATE GOOD BEFORE

[illegible] in a hurry to [illegible] for the Improved LPC Motor Scraper with its curved bowl bottom and offset cutting edge.

LAPLANT CHOATE
LAPLANT CHOATE

Improved FOR INCREASED PRODUCTION

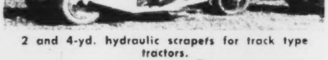
A few of the new features that cut down-time and increase hourly earnings

- NEW Heavy Duty Constant Mesh Transmission
- NEW 32-amp. Generator
- NEW 12 cu. ft. Piston Type Compressor
- NEW and Improved CCU and Controls
- NEW Water Pump and NEW Cast Type Radiator for More Efficient Cooling
- NEW Simplified Starting System—dash controlled

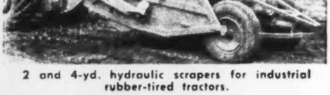
PLUS all these original high production features

- Big Capacity—17½ yards heaped
- Big Power—225 H.P. Diesel—16 H.P. per struck yard capacity
- Big Brakes—22″ x 7″ 4-wheel—air
- Positive Hydraulic Steering—Double Acting
- High Speed—up to 19.25 m.p.h.
- Easy Loading—curved bowl bottom—offset cutting edges
- Positive Forced Ejection plus high apron lift

6, 8 and 14-yd. cable scrapers for any make of track type tractor.



2 and 4-yd. hydraulic scrapers for track type tractors.



2 and 4-yd. hydraulic scrapers for industrial rubber-tired tractors.

LAPLANT CHOATE

MOTOR SCRAPERS
BETTER NOW

[illegible]

and lower operating and maintenance costs

Now you can have an even better LPC Motor Scraper, improved at every point so you can be sure it will stay on the job continually — complete your job on schedule — and assure good profits!

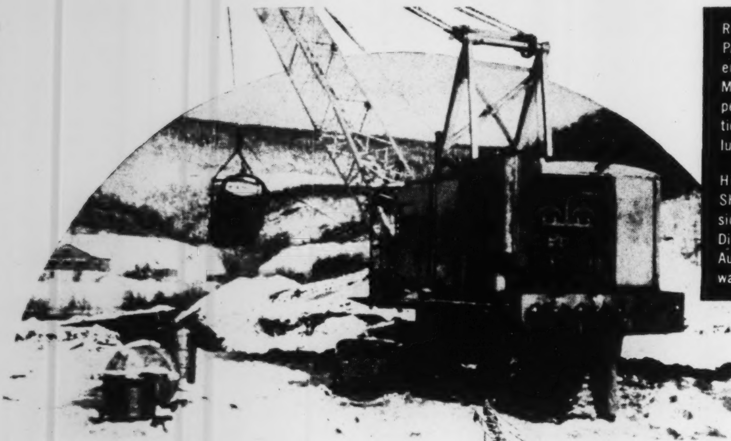
Increase production and profits — with the new transmission, you can use *all* of the 225 H.P. to handle capacity loads, at top speeds, up and down grades, even in tough operating conditions. Figure the added profit at your own bid prices of one additional load per hour over 10,000 hours of operation. The new 32-amp. generator provides all the "juice" needed for 'round the clock operation. Bigger air compressor for greater air output and more intermittent compressor operation. Improved cable control unit and controls save valuable seconds — give accurate spreading control.

24:00 x 29 24-ply traction type tires—interchangeable front and rear. 21:00 x 29 also available.

Add these and other new and improved features to the original proven high production features and you'll see why LaPlant-Choate Motor Scrapers give you the lowest possible cost per yard — per hour — per day for the long life of the unit.

Ask your nearest LPC distributor to show you a Motor Scraper in operation and for the complete details of all the improvements which mean more profitable earthmoving for you. LaPlant-Choate Manufacturing Co., Inc., Cedar Rapids, Iowa — 1022 77th Ave., Oakland, Calif.

HIGH SPEED EARTHMOVING EQUIPMENT

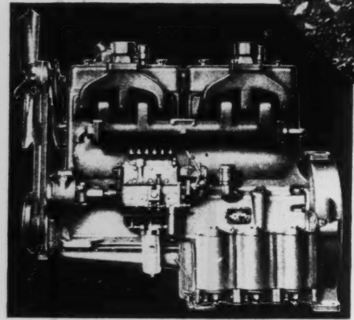


RHOADS CONTRACTING CO., ASHLAND, PA., says . . . "excellent results experienced thru new Waukesha Diesel Engine, Model 6-WAKD in our Marion shovel. The performance has exceeded our expectations, with quite a saving in fuel and lube oil."

●

HICKORY CONTRACTING COMPANY, SHAMOKIN, PA., in speaking of conversion of their Marion Shovel to Waukesha Diesel Power, says: "The know-how of Auto Gears & Parts Co., Inc., engineers was really assuring."

2 CONTRACTORS... ..2 SHOVELS...



WAUKESHA Super-Duty DIESEL (Model 6-WAKD) six cylinders, 6¼-in. bore x 6½-in. stroke, 1197 cu. in. displacement, powers these Marion shovels.

WAUKESHA *Diesel* POWER

does a better job for BOTH!

For shovel work particularly, the most outstanding of all Waukesha Diesel characteristics is smoothness and trigger-quick response to the operator's every command. Lively, yet shudder-free, it meets every power and load demand with all the smoothness of steam. And that's a new experience, even to an old Diesel hand. Clean burning, its fuel economy is excellent. Built with rugged simplicity. Such features as hard, wet cylinder sleeves, simple overhead valve mechanism, gear-driven water pump cooling, and pressure oiling—all make the Waukesha Diesel easy to understand and simple to service. For all the details, send for Bulletin 1415.

WAUKESHA MOTOR COMPANY • WAUKESHA, WISCONSIN

NEW YORK • TULSA • LOS ANGELES

These wood preservatives
1. REPEL TERMITES
2. RESIST DECAY
3. RETARD FIRE
and leave wood clean, paintable and safe to handle!

NEW DU PONT COPPERIZED CZC

(CHROMATED ZINC CHLORIDE)

To give wood *extra-long* protection against termites and decay, specify pressure treatment with Du Pont Copperized CZC. In addition, this new salt-type preservative gives timber and lumber all the time-tested advantages of standard CZC treatment. The effectiveness of Du Pont Copperized CZC is shown by these six significant tests—leach block test, hardware corrosion test, accelerated service test, pilot plant treatments, strength tests and glow tests.

STANDARD DU PONT CZC

(CHROMATED ZINC CHLORIDE)

A favorite for many years, Du Pont CZC is a *more economical* preservative treatment to specify when protection against fire is your main objective. It also gives timber and lumber good protection against termites and decay . . . leaves wood clean, easy to paint and safe to handle.

Which of these outstanding wood preservatives to specify, depends on your particular needs. Each gives timber and lumber long-lasting, dependable protection. We suggest you consult your nearest wood preserver.

MAIL COUPON NOW
for complete facts about these two outstanding Du Pont wood preservatives.

E. I. du Pont de Nemours & Co. (Inc.)
Grasselli Chemicals Department E.N.R.-2.
Wilmington 98, Delaware

Please send me information on Copperized CZC and standard CZC.

*Name*______________________________

*Firm*______________________________

*Street*______________________________

*City*________________ *State*__________

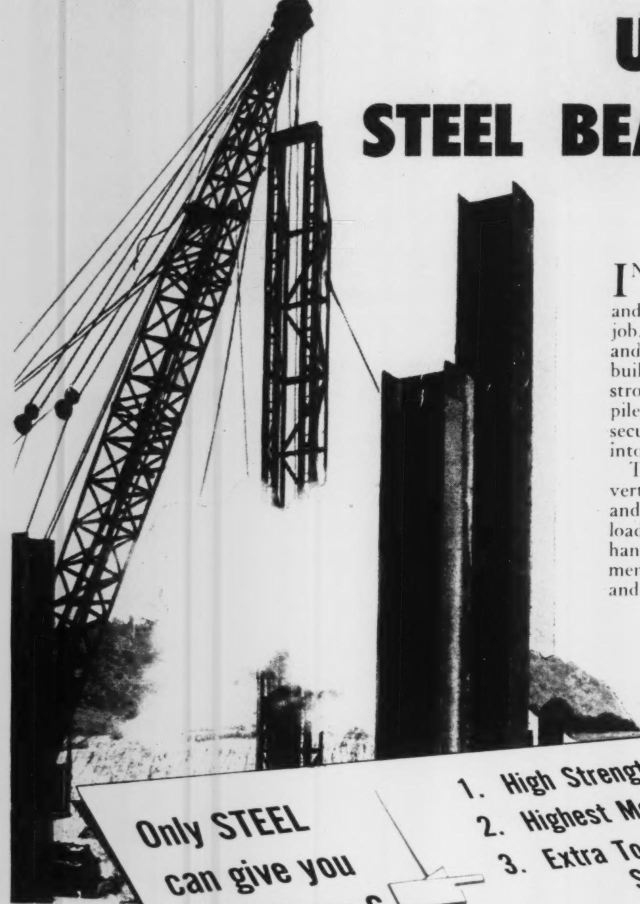
DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Helping to Build a

By providing safe and permanent foundations

U·S·S STEEL BEARING PILES



IN U·S·S Steel H-Beam Bearing Piles, engineers have found lasting safety and economy for every type of foundation job. On large jobs and small, in fresh water and, when encased, in salt water, under buildings, bridges and viaducts, these strong, permanent, easily driven H-Beam piles have proved their ability to provide a secure means of carrying foundation loads into stable mediums lying at great depth.

Their capacity for high unit loads, both vertical and horizontal, permits fewer piles and fewer driving operations for a given load. U·S·S Steel Bearing Piles are readily handled in the field by ordinary equipment, are easy to splice, eliminate jetting and withstand rough handling.

Only STEEL can give you all of these 6 structural advantages

1. High Strength-Weight Ratio
2. Highest Modulus of Elasticity
3. Extra Toughness and Shock Resistance
4. Versatility of Application
5. Great Durability
6. Ultimate Economy

Better America

By keeping earth and water in place

U·S·S
STEEL SHEET PILING

IN cut-off and core walls for dams and dikes, in wharves, slips, seawalls, in bridge pier retaining walls and in railroad and highway abutments, U·S·S Steel Sheet Piling offers easily installed construction that is strong, rugged and lasting. Forming a continuous wall, U·S·S Steel Sheet Piling offers an invaluable and versatile construction medium for any project involving the retention and control of earth or water, it offers the double advantages of speed and economy.

U·S·S Steel Sheet Piling is made of straight-web, arch web, and Z-sections in a complete range of sizes and sections.

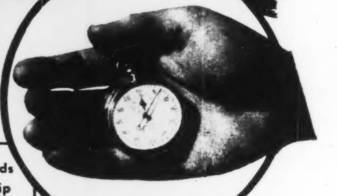
CARNEGIE-ILLINOIS STEEL CORPORATION, PITTSBURGH AND CHICAGO
COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM, SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

UNITED STATES STEEL

WE CAN INCREASE YOUR YARDAGE 50 TO 100%

It's a Guarantee

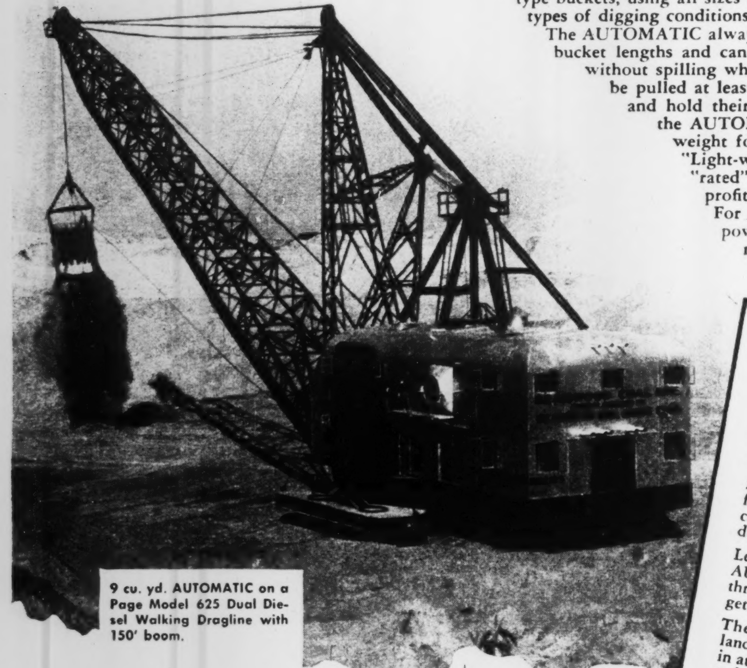


Type of Bucket	Load Time	Dump Time	Jockeying Time	Total Time	Full Loads Each Trip
AUTOMATIC	3 to 7 sec.	2 to 4 sec.	0 sec.	5 to 11 sec.	100%
Ordinary Type	7 to 16 sec.	4 to 7 sec.	2 to 6 sec.	13 to 29 sec.	85%

THESE are the facts proven by numerous tests made recently between the Page AUTOMATIC and ordinary type buckets, using all sizes from 3/8 to 30 cu. yd. in various types of digging conditions.

The AUTOMATIC always gets a full load within 1 to 2 bucket lengths and can be picked up immediately without spilling while ordinary buckets have to be pulled at least 4 to 6 bucket lengths to get and hold their loads. Another point about the AUTOMATIC—it is always the correct weight for maximum digging efficiency. "Light-weight" buckets of larger "rated" capacity cannot match the profit-making ability of a Page.

For more yardage per day, lower power costs and minimum maintenance, be sure your next dragline bucket is a Page AUTOMATIC.



9 cu. yd. AUTOMATIC on a Page Model 625 Dual Diesel Walking Dragline with 150' boom.

GET THE FACTS TODAY

Call or write for details on how to make a time study with your own stop-watch for positive proof—or better still, ask for a Page engineer to call and prove these facts without any obligation.

25 to 45% less power required for day-after-day operation because the AUTOMATIC loads, dumps and handles faster.

Less maintenance because the AUTOMATIC is not worn out through excessive dragging to get its load.

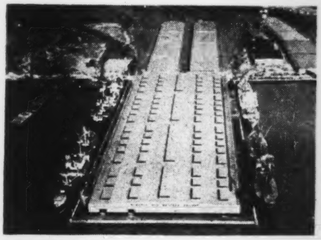
The AUTOMATIC always lands in digging position, digs in at first pull on the load line and never produces windrows.

Send for Bulletin 2049

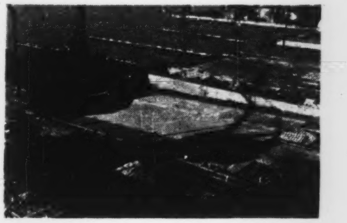
PAGE *Automatic*

DRAGLINE BUCKETS and WALKING DRAGLINES

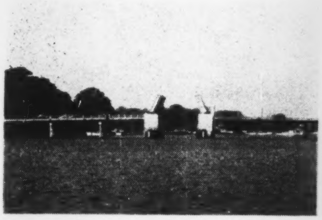
PAGE ENGINEERING COMPANY
Clearing Post Office • Chicago 38, Illinois



Pier "N," Norfolk and Western Railway Co., Norfolk, Va.



Shipways, Newport News, Va., Newport News Shipbuilding & Dry Dock Company



Spa Creek Bridge, Annapolis, Md., Maryland State Roads Commission

Outfall Sewer, Pinners Point, Portsmouth, Va., City of Portsmouth

Since the turn of the Century . . .

McLEAN CONTRACTING COMPANY has helped build a Greater America. We have been and are constructing a wide variety of engineering projects throughout the country for the Federal Government, States, Cities and leading industrial and utility companies.

Our experience and ability has made and is making it possible for us to successfully complete this variety of projects, involving unusual problems.

McLean Projects Include

BRIDGES	**RAILROADS**
PIERS	**INDUSTRIAL PLANTS**
BULKHEADS	**DAMS**
SHIPWAYS	**RESERVOIRS**
SUBAQUEOUS WORK	**TUNNELS**

McLean Contracting Company

General Contractors

1301 Fidelity Building, Baltimore 1, Md.

...only

LOCK JOINT

offers

all 8 of these advantages

Each of these characteristics is essential to a good water supply line, and Lock Joint Reinforced Concrete Pressure Pipe alone offers ALL 8 OF THESE ESSENTIAL QUALITIES.

1. Life Expectancy of Over 100 Years
2. Freedom from Corrosion, Tuberculation and Electrolysis
3. Permanent High Carrying Capacity
4. Freedom from Rupture, Blow-out or Collapse
5. Ability to Withstand Extreme Beam and Back Loads
6. Designed to Any Pressure Common to American Water Works Practice
7. Low Initial Cost and Minimum Maintenance Charges
8. Expansion Joints Installed with Maximum Ease and Economy

LOCK JOINT PIPE COMPANY
Est. 1905
P.O. Box 269, East Orange, N. J.
PRESSURE PIPE PLANTS: Wharton, N. J. • Turner, Kan.

BRANCH OFFICES: Cheyenne, Wyo. • Denver, Colo. • Kansas City, Mo. • Joplin, Mo. • Valley Park, Mo. • Chicago, Ill. • Rock Island, Ill. • Wichita, Kan. • Kenilworth, N. J. • Hartford, Conn.

SCOPE OF SERVICES: Lock Joint Pipe Company specializes in the manufacture and installation of Reinforced Concrete Pressure Pipe for Water Supply and Distribution Mains in a wide range of diameters as well as Concrete Pipe of all types for Sanitary Sewers, Storm Drains, Culverts and Subaqueous Lines.

LOCK JOINT
Reinforced Concrete
PRESSURE PIPE

LOOK TO

P&H

FOR ADDED VALUES

Leadership

in EXCAVATOR PERFORMANCE

Since the first gasoline powered excavator was introduced, more than 30 years ago, P&H has led the way in progressive design and engineering.

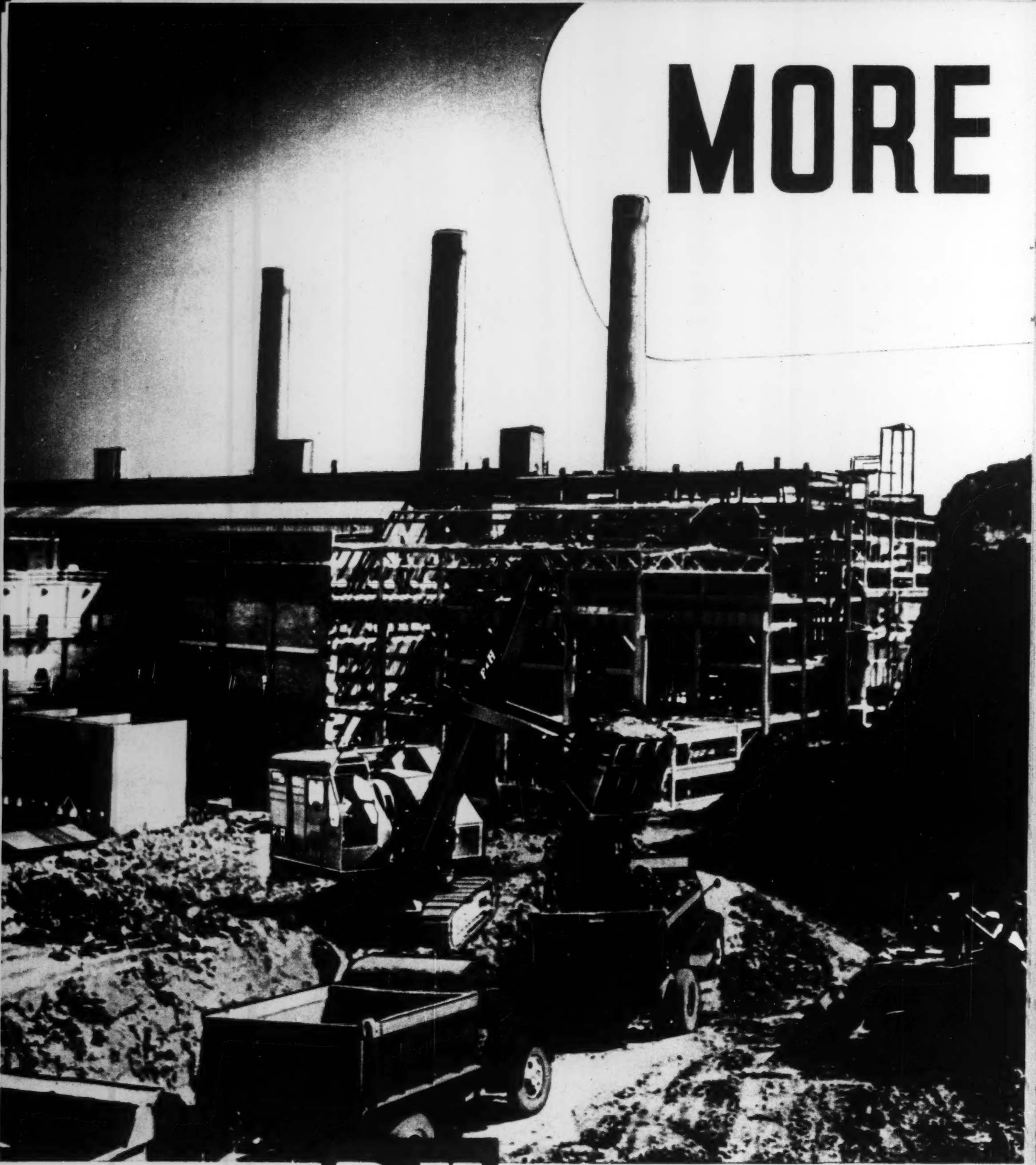
Today's P&H Excavators reflect the creative thinking — the advancements — that appeal to cost-conscious users. Here are some of the Added Values that set the pace in performance, in lower maintenance costs and in longer life.

For example, these P&H firsts . . . **are standard features on all machines up to 2 cubic-yard capacity.**

1st *with all welded construction* of rolled alloy steels — stronger — tougher. 1st *with true tractor type crawlers* — the most efficient traction ever put on an excavator. 1st *with direct acting hydraulic control* — smoother — faster — easier on both machine and operator. 1st *with planetary chain crowd* — faster retract — more accurate. Crowd chain outlasts from 20 to 30 crowd cables.

P&H service is unrivaled in the industry with a network of strategically located warehouses and service stations — plus factory trained servicemen at all dealer points.

GREATER DIGGING POWER — AN IMPORTANT P&H ADDED VALUE



LOOK TO **P&H**

FOR ADDED VALUES

(Above) A P&H Model 655 ($1\frac{1}{2}$ yard). Important features include all-welded construction of rolled alloy steels, low pressure hydraulic control — true tractor type crawler — and many others you can't get in other machines, or, if available, cost you extra.

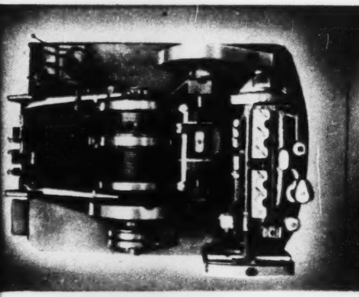
DIGGING POWER

per pound of weight

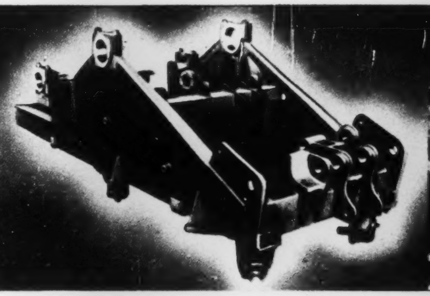
another P&H added value

Sit at the controls of a P&H and you'll know what we mean. It's *designed* — from crawlers to boom point — to put more *dig* at the tooth point! Deadweight's out! Live weight does it — makes the difference in faster, easier digging. And that means lower costs on any job.

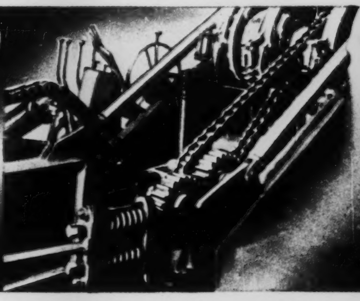
Here are some of the ways you gain maximum capacity in relation to total machine weight:



1. YOU SWING LESS DEADWEIGHT. Machinery units on upper deck are placed far back of center to counterbalance digging end. This trims off hundreds of pounds of clumsy ballast — peps up the swing — reduces strain.



2. YOU CARRY LESS TOTAL WEIGHT. This modern P&H revolving frame weighs only 2/3 as much as old style frames for same size machine. Yet rolled alloy steels, all-welded, make it the strongest for its size ever built.



3. YOU HAVE FULL ENGINE POWER ON EVERY BITE with P&H's planetary chain crowd. It's rapid-reversing—50% faster on retract. Action is smooth, responsive, accurate — you can control it to within 1 inch of grade.

Buy your next excavator on the basis of more digging power per pound of weight. You'll be money ahead — and years ahead — with P&H.

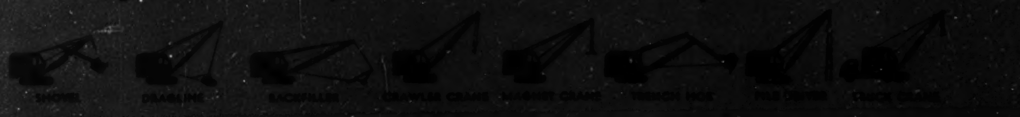
Ask your P&H Dealer to show you the new sound-color film "Added Values." Every excavator user should see it.

P&H EXCAVATORS
4404 W. National Avenue
Milwaukee 14, Wisconsin

HARNISCHFEGER CORPORATION
EXCAVATORS · ELECTRIC CRANES · ARC WELDERS · P&H · HOISTS · WELDING ELECTRODES · MOTORS

SEE YOUR P&H DEALER!

P&H Excavators and Truck Cranes are more easily converted for the various types of service shown below — with hoist and digging drums on one shaft, the need for auxiliary shafts and gearing is eliminated. You also have a choice of gas, Diesel or electric power. Ask for literature on the size you need.



look to P&H for added values

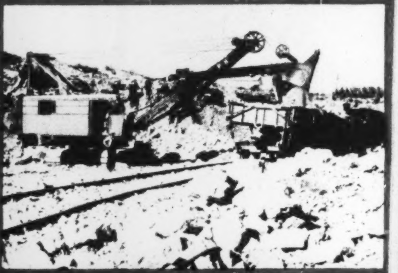
OTHER P&H EQUIPMENT FOR THE *Construction Industry!*

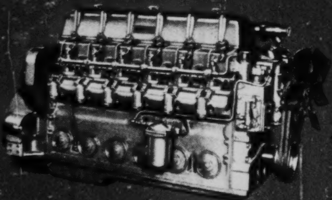
Designed and built to the same high standards of excellence as P&H Excavators, these P&H products offer Added Value performance on their specific jobs. Write for literature.

P&H SOIL STABILIZERS. For soil-cement or bituminous stabilization of roads, base courses, airports, etc., this machine performs ALL operations (except compaction) in a single pass and with only one operator.

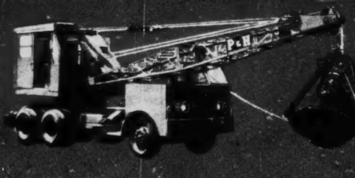
P&H LARGE EXCAVATORS, built in diesel and electric models through 6 cu. yds. capacity. These models offer many exclusive features including P&H "Magnetorque"* which transmits power electro-magnetically, without friction — without wear.

*T.M. of Harnischfeger Corporation for electro-magnetic type clutch.

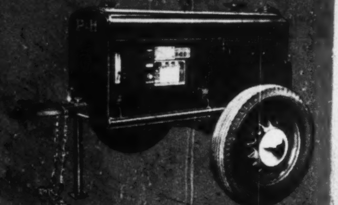




P&H DIESEL ENGINES. P&H Diesel Engines feature simpler servicing with patented cylinder head and liner assemblies, removable as units. Built in 2, 3 and 6 cylinder models. 2-cycle.



P&H TRUCK CRANES. Built complete by P&H (truck included). P&H Truck Cranes are dual-powered for greater flexibility on the highway — more action on the job. Easily converted to shovel, dragline, clamshell, hoe or pile driver.



P&H PORTABLE WELDERS — for all maintenance and repair needs. Two and 4-wheel models for easy towing, providing all field and shop services; skid mounted and stationary models and AC welders. P&H offers a complete line of AC and DC welding electrodes for all needs.

Literature is available on all sizes and types of P&H Equipment. *Write Today*

P&H EXCAVATORS

HARNISCHFEGER CORPORATION

4404 W. National Ave. Milwaukee 14, Wisconsin

EXCAVATORS · OVERHEAD CRANES · HOISTS · ARC WELDERS and ELECTRODES · SOIL STABILIZER · CRAWLER and TRUCK CRANES · DIESEL ENGINES · CANE LOADERS · PREASSEMBLED HOMES

1875-1949

WINSTON BROS. COMPANY

CONSTRUCTORS and ENGINEERS
MINNEAPOLIS, MINNESOTA

74 Years of Construction Service

TO OWNERS IN

NORTH and SOUTH AMERICA

in

RAILROAD CONSTRUCTION AND TRACKLAYING
MINE STRIPPING AND ORE REMOVAL
HIGHWAY GRADING AND PAVING
DAMS AND BRIDGES
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INDUSTRIAL AND INSTITUTIONAL BUILDINGS
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WINSTON

EASY, INEXPENSIVE SOIL COMPACTION

The New BARCO RAMMER

Rammer—Starting

Rammer—Jumping

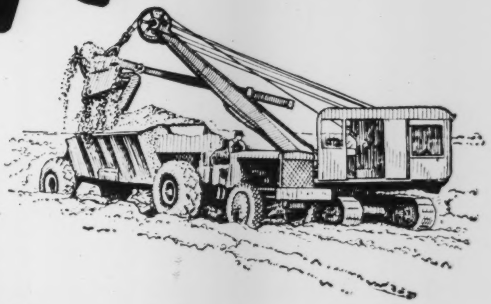
The new Barco Rammer is faster and more effective than any other type of tamper. It is easier on the worker, enables him to get more work done in less time, and at *lower cost.* Although rollers may do the compaction on large projects, they cannot reach locations close to abutments, culverts, walls and so on. But the new Barco Rammer remedies this situation, gives specified compaction. On large backfill tamping where a ditcher is used, the Barco Rammer works quickly and effectively. Today, with Federal, State and City authorities, as well as private corporations devoting more and more attention to these problems, the best answer is the Barco Rammer—the *entirely new* machine with the *entirely new method* of securing soil compaction. For more information write Barco Manufacturing Company, 1814 Winnemac Avenue, Chicago 40, Illinois. In Canada: The Holden Co., Ltd., Montreal, Canada.

BARCO

GASOLINE RAMMER

FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

Amsco Dipper Teeth



WESTERN POINT
(Patented)

A tough, long-wearing, reversible tooth for all types of digging operations. Its vertical-wedge fastening system insures quick, easy removal and replacement.

WHISLER POINT
(Patented)

For exceptionally hard service. Widely used on large dippers in mining ore and stripping coal. The wedge and C-clamp in the assembly serve to force the "crotch" of the tooth tight against the dipper lip and insure a snug fit between the tooth and the base.

* * *

In addition to the above, Amsco also manufactures other dipper teeth in a wide range of designs for any kind of service. For details, see Amsco Bulletin 547-DS.

To avoid loose Tooth Trouble

Poorly fitting dipper teeth can't last long. Any play in tooth fit means rapid wear and possible breakage of the tooth base. So specify Amsco when ordering replacement teeth. You can always be sure of a correct fit; every dipper tooth produced by Amsco is checked on a master base.

Made of tough austenitic manganese steel, Amsco dipper teeth work harden radically under heavy impact and develop a plowshare polish which greatly lengthens service life. This hard, shiny surface is self-renewing during the entire life of the part.

Other Amsco products are: Welded-type, renewable lip, and Missabe dippers; dipper parts; crawler shoes, rollers, treads and tumblers; dragline buckets and parts; pulling chains; and Amsco welding products for hardfacing and repair.

AMERICAN
Brake Shoe
COMPANY

AMERICAN MANGANESE STEEL DIVISION
CHICAGO HEIGHTS, ILL.

Foundries at Chicago Heights, Ill., New Castle, Del., Denver, Colo., Oakland, Calif., Los Angeles, Calif., St. Louis, Mo.
Offices in principal cities. In Canada: Joliette Steel Limited, Joliette, Que.

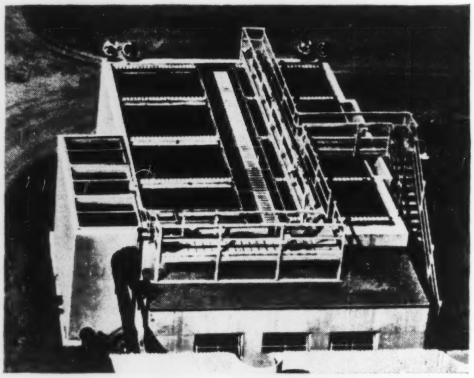
Building a greater America—

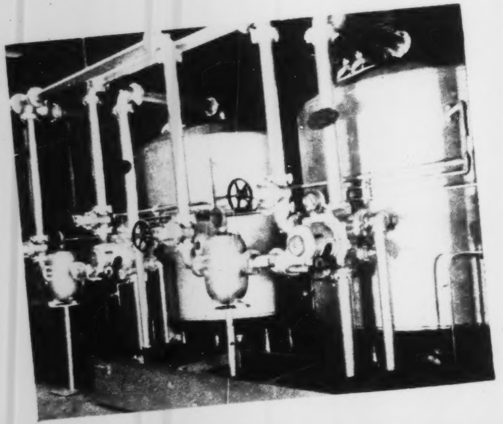
The purifying and softening of municipal water supplies, resulting in healthier, more comfortable living—the conditioning of water to improve product quality and reduce production costs—have played a major part in the building of a greater America.

As the leading designer and manufacturer of *both* the equipment and materials needed for water conditioning, Permutit has made substantial contributions to municipal and industrial progress. Here are just a few of the outstanding Permutit processes for water conditioning:

1. Precipitation

The Permutit® Precipitator offers the newest, most efficient means of removing impurities from water. Operating on the principles of precipitation, adsorption, settling and upward filtration, the Permutit Precipitator allows savings of up to 50% in ground space requirements. Savings in quantities of chemicals and adsorbents range up to 40%; in treatment time, up to 75%. Capacities vary from 1,000 to 10,000,000 gallons per day for a single unit. Applications include softening; removal of turbidity, color, taste, odor, alkalinity, silica and fluorides.



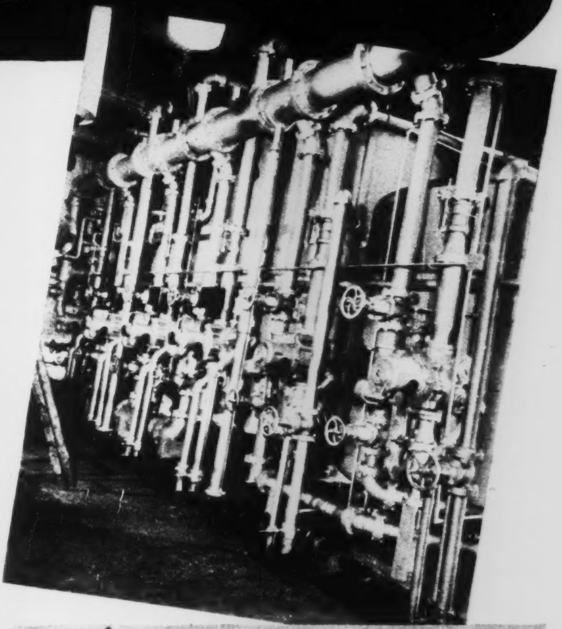


2. Water Softening

The zeolite process for softening water—recognized as the simplest method—was originated and has been brought to its highest degree of efficiency by The Permutit Company. The Permutit line of equipment includes fully automatic types with simplified controls and manually controlled multiport valve types, both offering improved performance. Permutit is prepared to furnish the correct type of zeolite (ion exchanger) for specific requirements.

WATER CONDITIONING HEADQUARTERS FOR

these outstanding Permutit processes

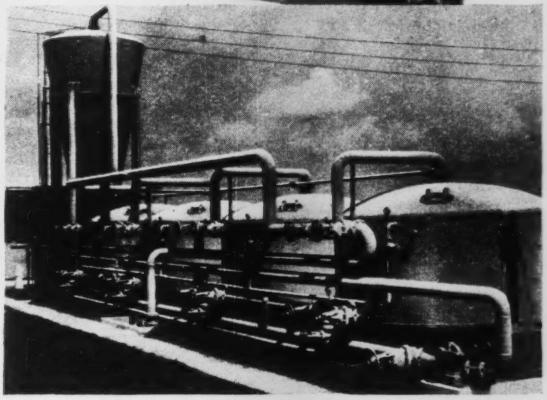


3. Iron Removal

Pulp, paper and textile mills, chemical plants, tanneries and other industries requiring water low in iron content depend on Permutit equipment. Permutit processes for iron removal include base exchange; oxidation by manganese zeolites; aeration, settling and filtration; and other processes to meet any specific requirement.

4. Cold lime-soda Treatment

Latest addition to the list of equipment for cold lime-soda treatment is the Spiractor®, which requires far less space and treatment time than earlier types of equipment. In the Spiractor, the precipitates accumulate on solid nuclei to form large, heavy granules that can be separated from the water at relatively high flow rates. No sludge is formed; the granules can be disposed of as easily as moist sand grains.



For full information on these or any other processes of water conditioning, write The Permutit Company, Dept. ENR-9, 330 West 42nd Street, New York 18, N. Y., or The Permutit Company of Canada, Ltd., Montreal.

Permutit

OVER 35 YEARS

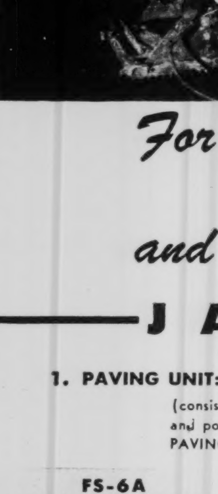
For FASTER PROGRESS BETTER WORK *and* LARGER PROFITS . .

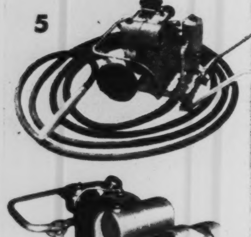
JACKSON

1. PAVING UNIT:

(consisting of electrically vibrated, manually guided paving machine and portable power plant) a great producer, ideal for MUNICIPAL PAVING, BRIDGE DECKS and HIGHWAY WIDENING. Strikes off to all crowns, undercuts at curb or sideform, works right up to and around manholes and other obstructions. Inexpensive.

FS-6A (FLEXIBLE SHAFT)





***2. SOIL COMPACTOR:**

Can be used to tremendous advantage in compacting granular backfill in BRIDGE APPROACHES, close to BRIDGE ABUTMENTS, under FACTORY FLOORS, along side FOUNDATIONS, under FOOTINGS, RAMPS, MUNICIPAL PAVEMENTS, SIDEWALKS and many other places. One man can easily guide two side by side. Delivers up to 4500 ½-ton blows per minute.

***3. SIDE FORM VIBRATOR:**

Works equally well mounted ahead of finisher screed or in rear of spreader. Controlled by finisher operator. Saves better part of two men's labor. Will not penetrate through concrete to subgrade.

4. MASS CONCRETE VIBRATOR:

This machine has a tremendously impressive record on nearly all of the nation's large dam projects.

5. HYDRAULIC VIBRATOR WITH 50 FT. REACH:

Highly dependable and efficient. Reaches hard-to-get-at places with minimum moves of power unit.

M-2 POWER PLANT

Capacity 2.5 KVA. Other models of 1.25 KVA and 5 KVA. All generate both single-phase and 3-phase 110 volt, 60 cycle AC and are equipped with permanent magnet generators requiring no adjustment or maintenance. For operating all types of vibrators, contractors' tools and lights.

AND MANY OTHER VIBRATORS:

Gas-engine driven, electric, flexible shaft types for general and mass construction, form vibrating, etc. FOR SALE OR RENT at Jackson distributors. Items marked * are manufactured for Jackson Vibrators Inc. See them at distributors of their line.

Descriptive literature on request.

ELECTRIC TAMPER & EQUIPMENT CO.

LUDINGTON, MICHIGAN

You don't lead in sales for 17 years unless you lead in value!

International Trucks have led in heavy-duty truck sales for 17 straight years!

WHAT HEAVY-DUTY TRUCKS offer the biggest value? The most exacting truck buyers in America have answered that one.

You can find their answer by looking at registration figures for new trucks with gross weight ratings of 16,001 pounds or over.

Those figures show that International Trucks have been *America's largest-selling heavy-duty trucks for 17 straight years!*

A heavy-duty truck is a major investment. You can bet your bottom dollar that the men who buy them don't give any line of trucks a vote of confidence like they've given International unless their profit and loss statements show them that it pays.

But don't think that International Trucks offer outstanding value in the heavy-duty field *alone.* There are 22 models of International Trucks plus 1000 specialized variations to meet individual hauling requirements. Gross weight ratings range from 4,400 to 90,000 pounds.

Trucks built to meet your specifications—No matter what model International Truck you buy, you get the basic values that have made International Trucks the largest-selling heavy-duty trucks in America for the past 17 years.

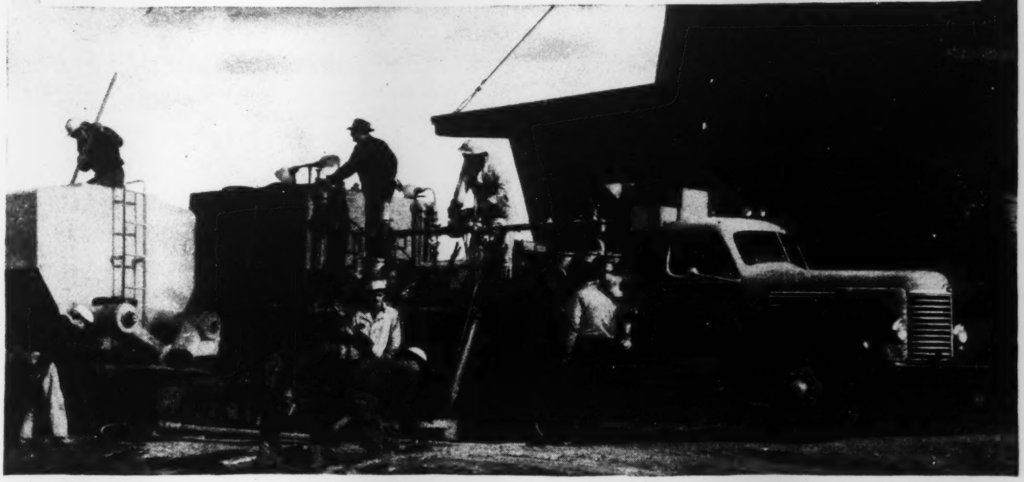
You get a rugged truck unweakened by a single compromise with passenger car design.

You get a long-lasting truck. *More than half of all the Internationals built in the last 42 years are still on the job.*

You get a truck specialized to meet your particular specifications; specified by a truck sales engineer who knows your business in terms of the demands it makes on trucks.

See your International Truck dealer or branch.

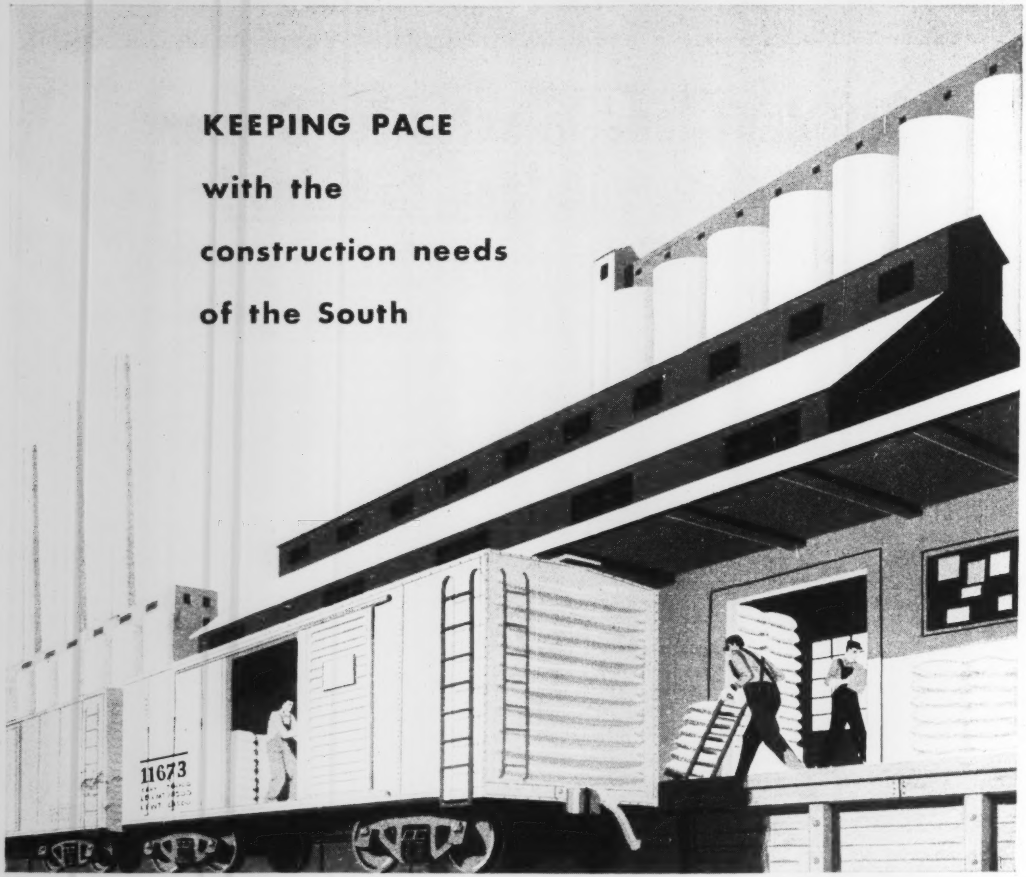
International Harvester Builds
McCormick Farm Equipment and Farmall Tractors
Motor Trucks and Industrial Power
Refrigerators and Freezers



INTERNATIONAL TRUCKS

INTERNATIONAL HARVESTER COMPANY • CHICAGO

FIRST IN HEAVY-DUTY TRUCK SALES FOR 17 STRAIGHT YEARS



GREAT DEVELOPMENTS ARE TAKING PLACE IN THE SOUTH

Across the Southern states, these famous brands of cement are arriving at the jobsites. Blueprints are becoming skylines. Industry, commerce, agriculture and housing are moving ahead.

This year we are able to deliver substantially more cement in certain areas than before. Plant enlargements undertaken immediately after World War II are now in production. Our program of plant improvement continues.

***TRINITY DIVISION:* DALLAS, FT. WORTH, HOUSTON**

***FLORIDA DIVISION:* TAMPA**

***SIGNAL MOUNTAIN DIVISION:* CHATTANOOGA**

TRINITY

FLORIDA

SIGNAL MOUNTAIN

PORTLAND CEMENTS

GENERAL PORTLAND CEMENT COMPANY

FOR FASTER RIVETING USE CLECO RIVETERS!

EXCLUSIVE FEATURES

make Cleco Riveters faster in action, easier to handle, and less tiring to the operator. The result is faster, more uniform riveting at lower cost. For full information, write for Bulletin No. 82.

ALL SIZES

Cleco makes a complete line of riveters. Heavy duty riveters—capacities to 1⅜" . . . Aircraft riveters — capacities to 7/16" rivets . . . Squeeze riveters — capacities to ¼" rivets.

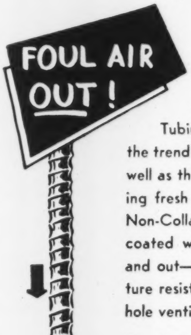
● **SEE YOUR CLECO DEALER FOR:** Grinders — Sanders — Rotary Drills — Riveters — Sand Rammers — Chippers — Scaling Tools — Impact Wrenches — Screwdrivers — Hose Fittings — Sump Pumps.

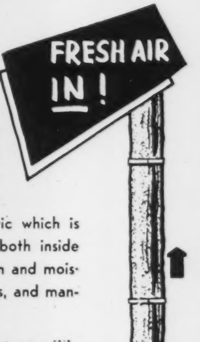
CLECO DIVISION

of the REED ROLLER BIT COMPANY

P. O. Box 2119, Houston 1, Texas

NOW! NON-COLLAPSIBLE MineVent FLEXIBLE TUBING!





Now MineVent Non-Collapsible Tubing has been made available to meet the trend towards having foul air pulled out, as well as the long established practice of pumping fresh air into tunnel projects. MineVent Non-Collapsible Tubing is made from a fabric which is coated with a tough rubber-like compound, both inside and out—it's completely air-tight and abrasion and moisture resistant. Ideal for portable heating units, and manhole ventilation.

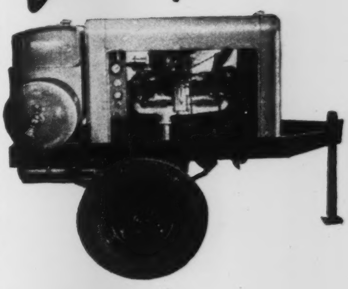
Simple interlocking sections provide for instant assembly of any length desired. Six to one lengthwise collapsibility permits packing fifteen feet lengths into a space 30" long. Comes in sizes 5" to 24" in diameter.

Send for Bulletin 749.

AMERICAN BRATTICE CLOTH CORP.

240 Buffalo St. **Warsaw, Ind.**

Here's the COMPRESSOR for you!



NEW!

. . A new SMITH Compressor with more capacity, smooth operation, economy . . long life!

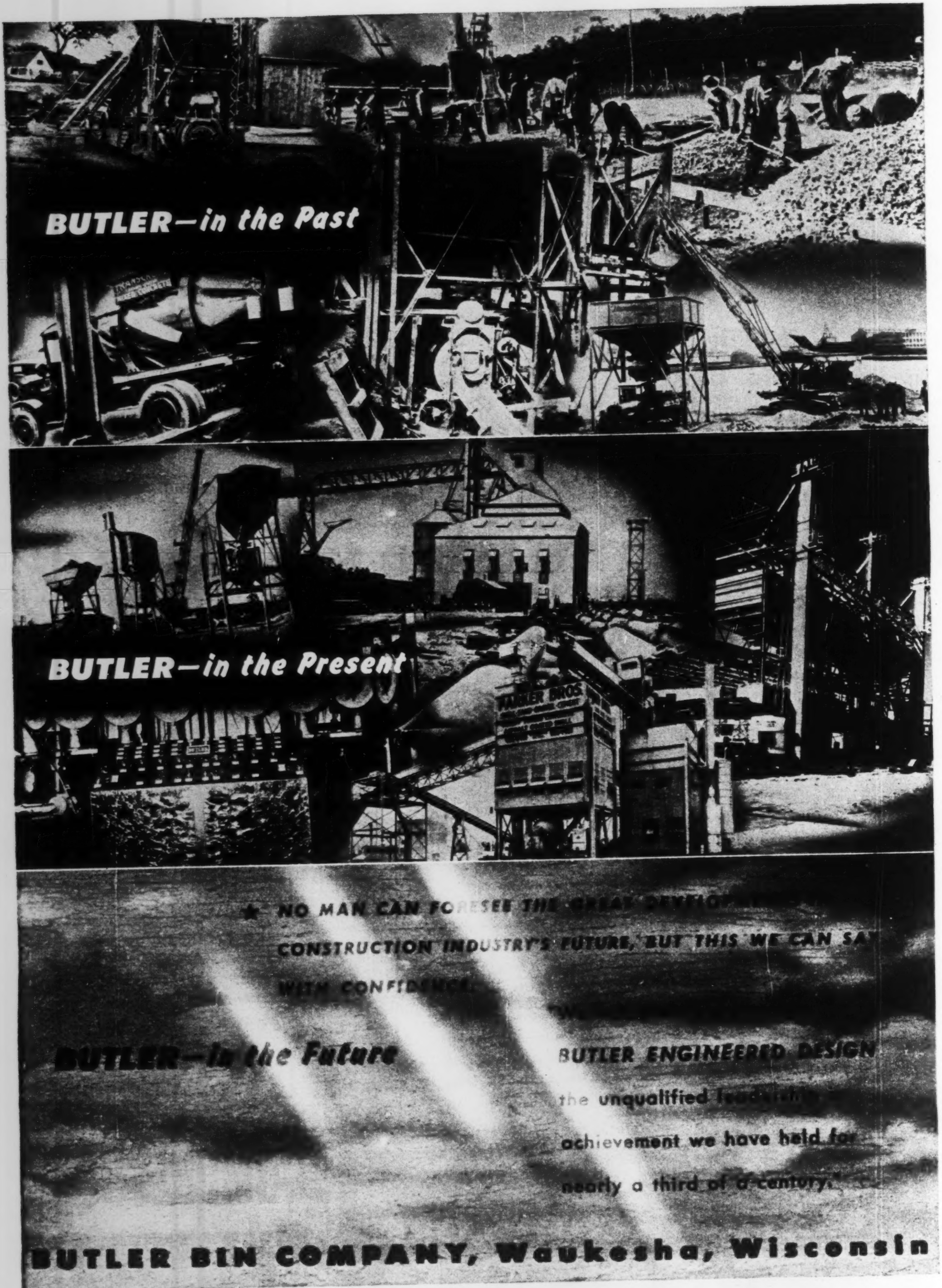
Powered with a famous CHRYSLER Industrial Engine—3 cylinders for power—3 for compression. Evenly spaced power impulses. Capacity 70 cu. ft. at 80 lbs. pressure. Throttle operates about ⅓ open when operating at 150 lbs. pressure. Built for heavy duty without excess bulk and weight. Engine parts available at Chrysler, DeSoto, Dodge truck dealers.

Write for complete facts about the SMITH Model 250!

Smith AIR COMPRESSORS

GORDON SMITH & CO.

430 College St. Bowling Green, Ky.



BUTLER—in the Past

BUTLER—in the Present

BUTLER—in the Future

★ NO MAN CAN FORESEE THE GREAT DEVELOP[illegible] CONSTRUCTION INDUSTRY'S FUTURE, BUT THIS WE CAN SAY WITH CONFIDENCE: "We [illegible] BUTLER ENGINEERED DESIGN the unqualified leadership [illegible] achievement we have held for nearly a third of a century."

BUTLER BIN COMPANY, Waukesha, Wisconsin

the generator unit is a hundred feet away

But it makes no difference — because of the easily handled electric cable of this new, lightweight, high frequency, electric vibrator . . . no need for flexible shafts . . . necessary movements of generator unit are minimized.

Built for one-man operation, the CP-220 Vibrator is designed for concretes of 2″ slump and over; walls, footings, columns, floor and roof slabs; precast piles and similar products.

Two CP-220 Vibrators are powered with a CP-2KW gasoline-driven Generator, 220 volt, 3-phase, 180 cycle.

Write for further information on the CP-220 or other CP Vibrators.

* * *

Every requirement for mass or reinforced concrete is met by seven different models of CP Vibrators — pneumatic and electric — including the new CP-5190 High Frequency Vibrator for low-slump concrete specified on current dam projects.

CHICAGO PNEUMATIC
TOOL COMPANY
General Offices: 8 East 44th Street, New York 17, N. Y.

PNEUMATIC TOOLS • AIR COMPRESSORS • ELECTRIC TOOLS • DIESEL ENGINES
ROCK DRILLS • HYDRAULIC TOOLS • VACUUM PUMPS • AVIATION ACCESSORIES

"Tag Master"

TAGLINE ADVANTAGES

You never had before!

1 Tagline pull is adjustable to suit job.

2 Tagline pull remains constant and uniform at truck level or 70 feet below machine.

3 Tagline pull is automatic.

4 The pull on the tagline can be increased INSTANTLY with manual control feature to manipulate a clamshell or grapple.

5 Accurate loading WITHOUT moving boom.

6 Accurate casting WITHOUT moving boom or machine.

7 Permits digging over a 25 foot range WITHOUT moving boom or machine.

8 Installed inside cab . . . no extra weight on boom.

9 Simple adjustment converts Tagline to a Dipper Trip for use with a Shovel Front.

MORIN COMBINATION TAGLINE WINDER AND DIPPER TRIP

The only Tagline
EQUALLY EFFICIENT
AS A DIPPER TRIP

MORIN
MANUFACTURING CO., INC.
WEST SPRINGFIELD, MASS.

SEND COUPON NOW

Gentlemen: Kindly send details of the "Tag-Master". Here is the make, size and model number of the crane (or shovel) I operate:

. . . .

. . . .

Name . . . .

Company . . . .

Address . . . .

REDUCE TIME PER JOB
CUT WORK COST PER HOLE

OLD WAY
NEW WAY WITH CONCRETE TERMITE ROTARY DRILLS

Concrete Termite

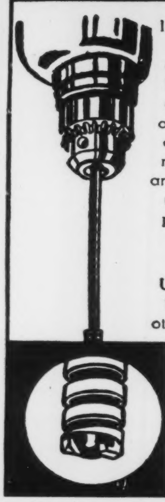
Where 100 to 200 perfect accurate holes in concrete and other abrasive materials are needed use this patented Rotary Drill

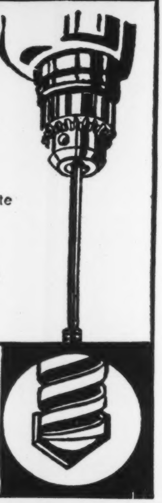
U.S Pat 2425132 other pats.

Brick Termite

For an inexpensive Rotary Drill where limited number of accurate perfect holes in Brick, Concrete and other abrasive materials are needed

Pats. Pending

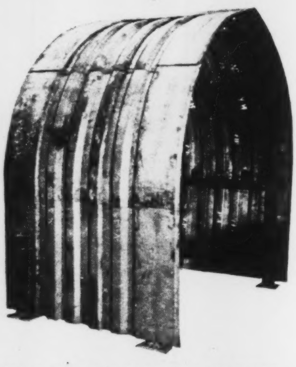




WRITE FOR CATALOG & PRICES.
Dealers needed to service inquiries.
Manufactured by
CONCRETE TERMITE DRILL CO.
2081 Foothill Blvd.
Pasadena, Calif.

SAFE — FAST — LOW COST

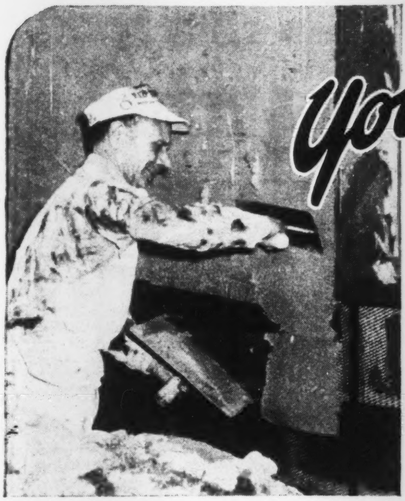
"Commercial" OFFERS A NEW PRODUCT FOR TUNNEL BUILDERS!



WATER BAR LAGGING

A purlin plate lagging designed to divert water to the spring line . . . has generous laps at end joints to insure against inflow. Stiffeners are proper depth to carry loads. Write for complete information.

THE COMMERCIAL SHEARING & STAMPING CO. YOUNGSTOWN, 1, OHIO



You're on the beam

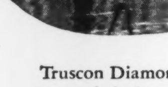
when you're working on Truscon Metal Lath Products

Bill Scullz of Morelli Brown Plastering Co., Inc., knows how easily you can lay on the plaster and do a bang-up job with Truscon Metal Lath backing you up. He's one of the gang that did such beautiful plastering in the Astoria Housing Project shown here.

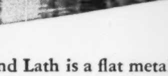
Tons of Truscon Diamond Lath, Corner Bead and Galvanized Tie Wire went into this tremendous group of apartments, assuring fine appearance of walls and ceilings for many years.

New York, City Astoria Housing Project,
Halletts Cove, Astoria, New York.
Contractor: Corbetta Construction Co., Inc.
Plasterer: Morelli Brown Plastering Co., Inc.
Architect: Harrison & Abramowitz

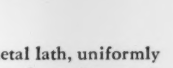
Truscon Diamond Lath is a flat metal lath, uniformly expanded throughout the entire sheet. Its use is almost universal, for it is adaptable for practically all classes of work—as a base for walls, partitions, ceilings, as a reinforcement for stucco, as a protection for steel beams and columns, and for protecting hazardous points in wood frame construction—such as ceilings under inhabited floors, especially over heating plants and coal bins, around flues, and back of kitchen ranges, stair wells, and under stairs. Diamond Lath has more openings in a given area, with a proportionate increase in the area of steel. The increased proportion of steel gives the sheets great rigidity. They are easily handled and quickly erected, and less time is taken in applying the scratch coat and truing up the wall than with ordinary diamond lath. The small openings prevent excess penetration of plaster, thus minimizing droppings. The larger number of openings permits the formation of more keys to give efficient bonding of the plaster to the lath. Write for catalog on Truscon Metal Lath and Accessories.



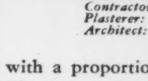
Diamond Lath



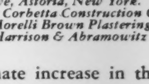
Herringbone Doublemesh Lath



3/8-inch Ribplex Lath



Self-Sentering Lath



Stucco Mesh

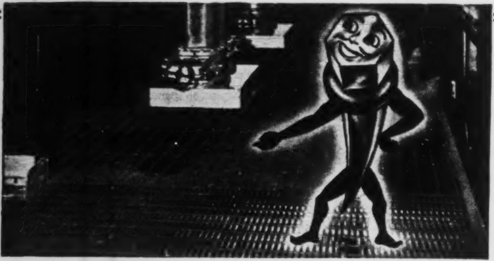
No. 8 Rib Steel Corner Bead

TRUSCON STEEL COMPANY
YOUNGSTOWN 1, OHIO
SALES OFFICES AND WAREHOUSES IN PRINCIPAL CITIES
Subsidiary of Republic Steel Corporation

TRUSCON SERVES THE PLASTERING INDUSTRY

BATES • GRATES

fit into every plant picture



If yours is an application like this—with pipes, installations and stairways cutting into the area—BATES • GRATES will give you neat, safe and strong open steel flooring.

Here's where BATES • GRATES win universal approval—where a series of stairways combine with short walkways. Safe and strong, plenty of light and ventilation all the way down.

YOU can use BATES • GRATES for flooring any area or running any stairways. They serve to advantage in many ways: They are strong, safe, easy to maintain, durable, provide maximum lighting and ventilation.

The simple directness of BATES • GRATES engineering accounts for these advantages. The key is the Hex Cross bar fillet-welded to stout main bars.

For open steel flooring and stair treads in your plant . . . *Get a Bid from BATES*

BATES • GRATES
WALTER BATES COMPANY, INC.
JOLIET, ILLINOIS

"BERG"

CONCRETE SURFACER MODEL A

"Berg" equipment is used extensively for surfacing and finishing applications on concrete construction.

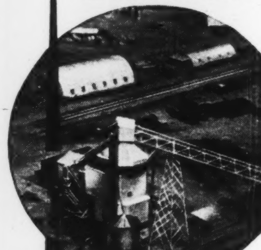
The many "BERG" Models available, permit exact selection for your particular application.

The distinctive "BERG" features give you the kind of results that are realized in better quality work, combined with lower costs.

"BERG" Heads and Attachments are interchangeable, thereby providing adaptability for vibrating, wire brushing, sanding and polishing applications.

THE CONCRETE SURFACING MACHINERY CO.
4667 SPRING GROVE AVE.
CINCINNATI 32, OHIO

Our 65th Year of Service to **CONTRACTORS**



Contract Bonds

- Bid & Performance Bonds
- Equipment Floaters
- Complete Casualty Insurance for Contractors

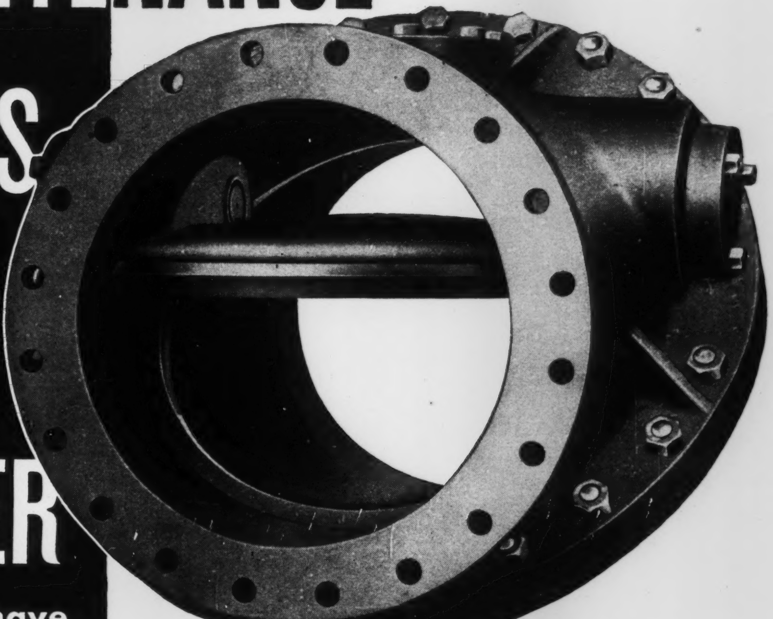
AMERICAN SURETY GROUP

AMERICAN SURETY COMPANY
NEW YORK CASUALTY COMPANY
SURETY FIRE INSURANCE COMPANY
100 Broadway New York 5, N. Y.

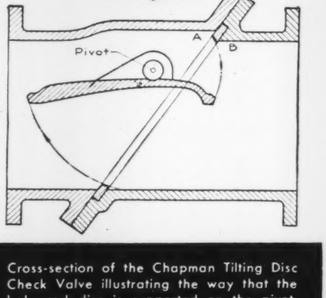
Agents and Brokers Everywhere

MAINTENANCE COSTS ARE LOWER

when you have *CUSHIONED CLOSING*



of — CHAPMAN CHECK TILTING DISC VALVES



Cross-section of the Chapman Tilting Disc Check Valve illustrating the way that the balanced disc is supported on the pivot, with arrows showing the travel of the disc. A feature of the design is that the disc seat lifts away from the body seat when opening, and drops into contact when closing, with no sliding or wearing of the seats.

That's right! Maintenance costs *are lower* with Chapman Check Valves . . lower because the balanced disc works *with the stream.* There's no slamming to cause destructive pipe line stresses and increase maintenance costs. Nor is there any rubbing on seats . . . the disc closes quickly and quietly with no sliding or wearing action.

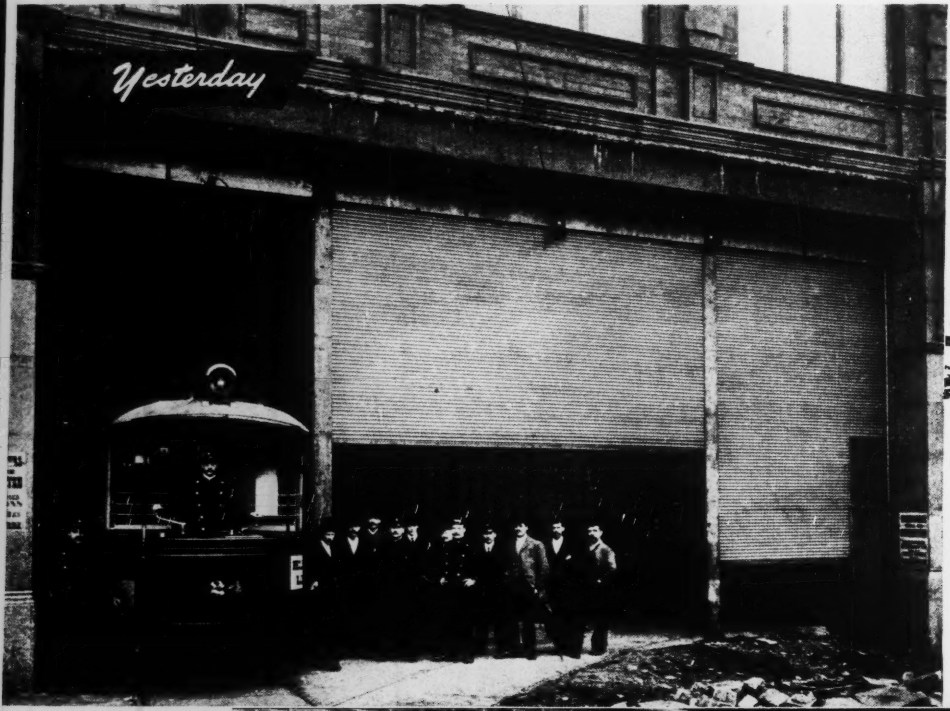
Yet that's only half the story. Head losses are actually 65% to 80% lower than for conventional type check valves. And, when used on pump discharge lines, substantial power savings are possible.

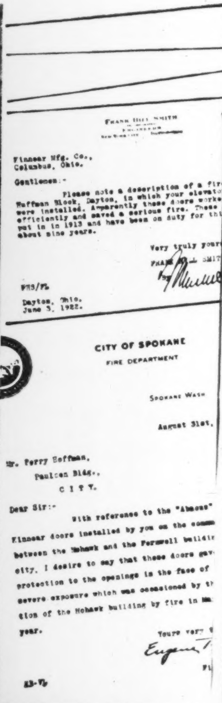
Why not write today for engineering data and reports of tests.

NO RUBBING
NO SLAMMING!

THE CHAPMAN VALVE MFG. COMPANY
INDIAN ORCHARD, MASSACHUSETTS

KINNEAR Rolling Doors





FRANK HILL SMITH

Kinnear Mfg. Co.,
Columbus, Ohio.

Gentlemen:-

Please note a description of a fir
Huffman Block, Dayton, in which your elevato
were installed. Apparently these doors worke
efficiently and saved a serious fire. These
put in in 1913 and have been on duty for th
about nine years.

Very truly your
FRANK HILL SMIT
by

FHS/FL

Dayton, Ohio.
June 3, 1922.

CITY OF SPOKANE
FIRE DEPARTMENT

Spokane Wash

August 31st,

Mr. Perry Hoffman,
Paulsen Bldg.,
C I T Y.

Dear Sir:-

With reference to the "Akmons"
Kinnear doors installed by you on the comm
between the Mohawk and the Fernwell buildin
city, I desire to say that these doors gav
protection to the openings in the face of
severe exposure which was occasioned by th
tion of the Mohawk building by fire in Ma
year.

Yours very
Eugene
Fi

EB-VB

Even in the days when horse-drawn street cars were trying to hold out against the new-fangled "trolleys", Kinnear Rolling Doors were a favorite of long standing.

Today
TERRACE PLAZA · SERVICE ENTRANCE

In the newest examples of modern, functional building design like Cincinnati's famous new Terrace Plaza Hotel, Kinnear Rolling Doors are widely preferred for efficiency, protection and beauty.

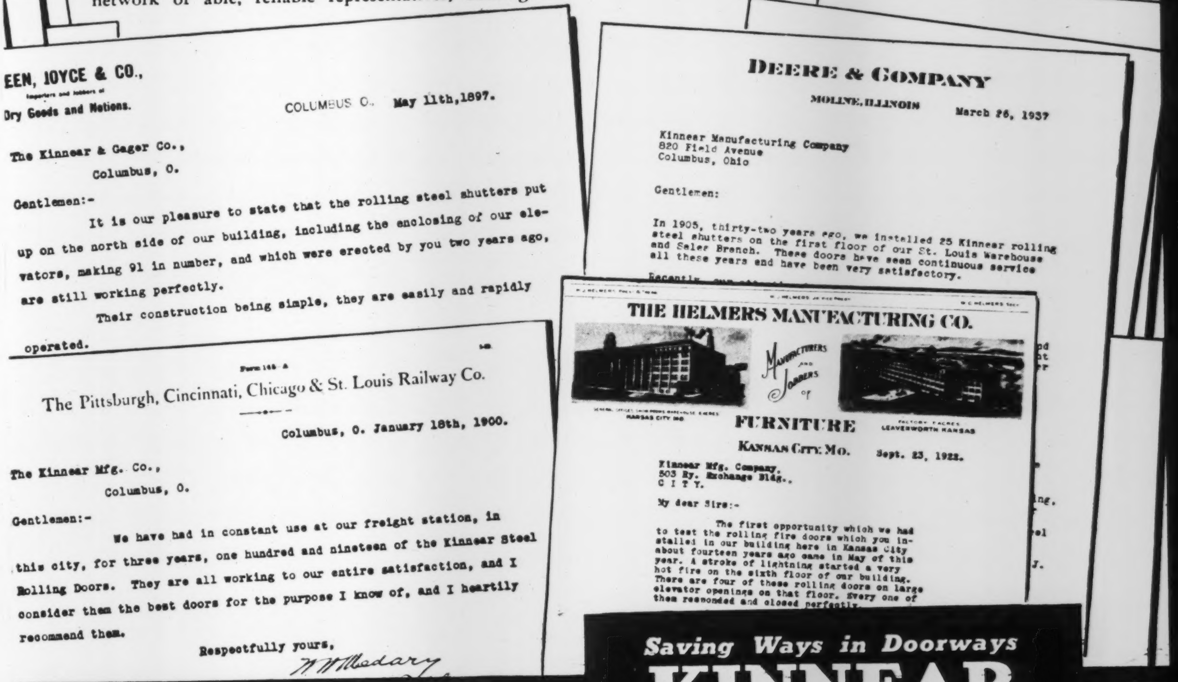
—through a Half-Century of Progress with the Building Industry!

At the turn of the century, Kinnear's files held scores of letters from enthusiastic users of Kinnear Rolling Doors. And there has been a steady stream of user-approval ever since.

The smooth, easy, space-saving efficiency, protection and durability of the Kinnear-originated, all-metal, interlocking-slat design was quickly approved in every phase of industry and commerce. But *the company that made these doors* was another strong factor in their universal acceptance.

Kinnear has specialized in building upward-acting doors exclusively. And to do this one job thoroughly, they have always maintained a nationwide network of able, reliable representatives, offering full cooperation with engineers and builders. Also, Kinnear's trained construction crews have been taking full responsibility for Kinnear Door installations when desired. *And to complete this service, records of every door sold are kept in fireproof vaults, so that accurate replacement parts are always available.*

TODAY, "Kinnear" is synonymous with leadership in doors the world over, because of this satisfactory *service* to engineers and builders, and satisfactory *door performance* for users everywhere for more than 50 years.



EEN, JOYCE & CO.,
Importers and Jobbers of
Dry Goods and Notions.

COLUMBUS O. May 11th,1897.

The Kinnear & Gager Co.,
Columbus, O.

Gentlemen:-

It is our pleasure to state that the rolling steel shutters put up on the north side of our building, including the enclosing of our elevators, making 91 in number, and which were erected by you two years ago, are still working perfectly.

Their construction being simple, they are easily and rapidly operated.

Form 165 A

The Pittsburgh, Cincinnati, Chicago & St. Louis Railway Co.

Columbus, O. January 18th, 1900.

The Kinnear Mfg. Co.,
Columbus, O.

Gentlemen:-

We have had in constant use at our freight station, in this city, for three years, one hundred and nineteen of the Kinnear Steel Rolling Doors. They are all working to our entire satisfaction, and I heartily consider them the best doors for the purpose I know of, and I heartily recommend them.

Respectfully yours,
W W Medary

DEERE & COMPANY

MOLINE, ILLINOIS March 26, 1937

Kinnear Manufacturing Company
820 Field Avenue
Columbus, Ohio

Gentlemen:

In 1905, thirty-two years ago, we installed 25 Kinnear rolling steel shutters on the first floor of our St. Louis Warehouse and Sales Branch. These doors have seen continuous service all these years and have been very satisfactory.

Recently

THE HELMERS MANUFACTURING CO.

Manufacturers and Jobbers of

KANSAS CITY MO

FURNITURE

FACTORY ACRES
LEAVENWORTH KANSAS

KANSAS CITY, MO. Sept. 23, 1922.

Kinnear Mfg. Company,
503 Ry. Exchange Bldg.,
C I T Y.

My dear Sirs:-

The first opportunity which we had to test the rolling fire doors which you installed in our building here in Kansas City about fourteen years ago came in May of this year. A stroke of lightning started a very hot fire on the sixth floor of our building. There are four of these rolling doors on large elevator openings on that floor. Every one of them responded and closed perfectly.

Saving Ways in Doorways

KINNEAR

ROLLING DOORS

Tomorrow

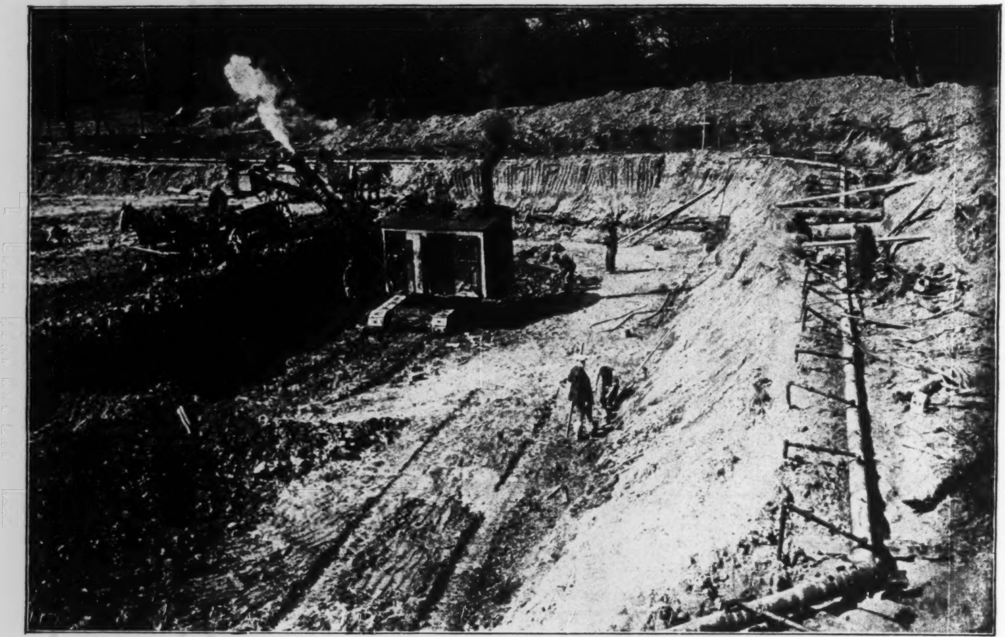
Like the principle of the wheel, the principle of Kinnear Rolling Doors will be as "modern" tomorrow as it is today—and as it was yesterday. That principle, combined with long-proven reliability of the Kinnear Doors is a promise of the best door value in the years ahead.

The KINNEAR Mfg. Co.

1820-40 Fields Avenue, Columbus 16, Ohio
1742 Yosemite Ave., San Francisco 24, Calif.

OFFICES AND AGENTS IN ALL PRINCIPAL CITIES

25 YEARS OF PUMPING PROGRESS



25 years ago: Excavating in the dry in swamp mud and clayey sand for a sewerage disposal plant.

Twenty-five years ago the Moretrench Wellpoint System got off to a flying start on a small wet sewer in Hackensack, New Jersey. Ever since, it has been contributing to the engineering achievements of America by dewatering wet excavations so successfully that contractors all over the country count on it to enable them to work with speed—with safety—"in the dry"—free from the fear of water.

Progress was slow at first. Contractors were reluctant to believe that a wellpoint system had at last been perfected that would work in any pervious soil. But as job after job was pumped successfully, word got around that the way to handle wet work *profitably*, was to predrain it with a MORETRENCH WELLPOINT SYSTEM.

Thousands of jobs have been dewatered by Moretrench—sewers, dams, bridges, buildings—projects of every type. Some were difficult, some easy. Each contributed in some way to building a greater America. Each added to our background of experience.

For true pumping achievement, Moretrench reviews with pride its long list of successfully dewatered jobs, and looks forward to serving the construction industry for many years to come by enabling contractors to work with progress and with profit . . . "in the dry".

MORETRENCH CORPORATION

90 West St.
New York 6

4900 S. Austin Ave.
Chicago 38, Illinois

7701 Interbay Blvd.
Tampa 9, Florida

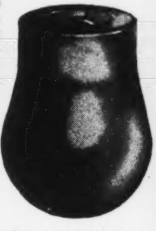
315 W. 25th St.
Houston 8, Texas

Rockaway
New Jersey

CAST SEMI-STEEL BALLS

FOR:
ROAD BUILDERS
WRECKERS
SCRAP YARDS

500 lbs.	$62.50
1,000 lbs.	101.00
1,500 lbs.	132.50
2,000 lbs.	165.00
3,300 lbs.	231.00
4,000 lbs.	290.00



RELEASE HOOKS
$30.00 Set

Immediate Delivery

F.O.B. FREDERICK, MARYLAND

FREDERICK IRON & STEEL, INC.
East 7th St., Frederick, Maryland

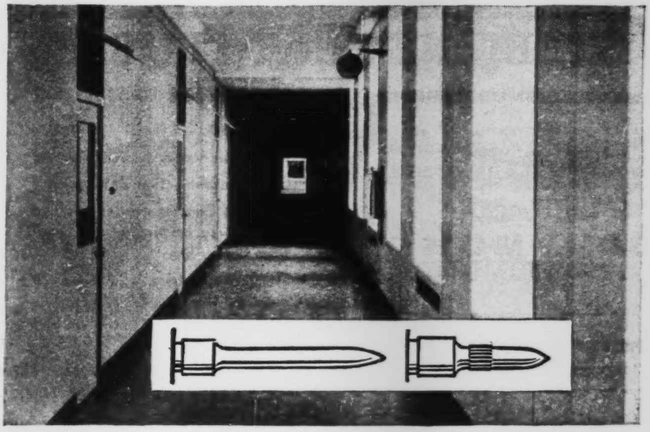
CHANNEL, HARBOR and EXPLORATION

SURVEYS

for Dredging and Bottom Determination . . .
The Modern *Electronic* Way . . .

THE BLUDWORTH MARIN
Model E.S. 123 Depth Recorder records depth and bottom materials. Write for details.

BLUDWORTH MARINE
92 GOLD STREET NEW YORK 7 N Y
[illegible]
SINCE 1926 MFRS OF PRECISION ELECTRONIC EQUIPMENT

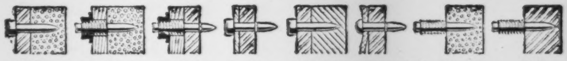


35,000 *Ramset* fasteners cut costs in this building

RAMSET FASTENING SYSTEM

Substantial cost savings and more rapid completion of the work resulted from the use of RAMSET FASTENING SYSTEM in this large building at Silver Springs, Maryland. Metal channels were fastened to concrete ceilings and floors with the light, portable RAMSET TOOL, using 35,000 RAMSET FASTENERS as illustrated. Each fastening took less than a minute working time—much faster and far less costly than old-fashioned drilling and chipping.

RAMSET SAVES TIME AND MONEY ON MOST FASTENING JOBS



Requiring no air, electric or other external power, because it is self-powered, the RAMSET TOOL is simple and easy to operate and can be used in small, confined spaces. In an hour, we teach any good workman to be a competent *"Ramsetter"*, able to do a wide variety of fastening jobs quickly and competently.

COMPARE "RAMSETTING" WITH YOUR PRESENT COSTS

Let us give you a 15-minute demonstration of the RAMSET SYSTEM —and prove with facts and figures how it will save you 50% or more in your fastening work. Just mail the coupon. *Stemco Corporation, Cleveland 16, Ohio.*

MAIL THIS COUPON

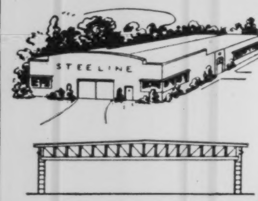
EN

Stemco Corporation,
Cleveland 16, Ohio
Please demonstrate with facts and figures how I can make a profit with RAMSET FASTENING SYSTEM.

Name ____________________
Address ____________________
City ____________________

STEELINE FLAT TRUSSES

for **MASONRY WALL CONSTRUCTION**



- Spans up to 60 feet.
- Four to six weeks delivery.
- Quality construction at low cost.
- Standard Trusses are flat, pitched all one way or pitched two ways from center line.
- Steel deck also furnished if desired. This will provide a fire safe foundation for insulation and built up roofing.

PITCHED ROOF SYSTEMS AND COMPLETE STEEL BUILDINGS ALSO AVAILABLE

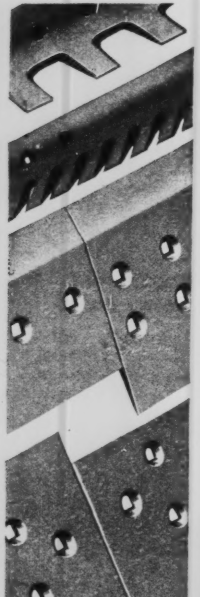
Gentlemen:

I am interested in more information on:

(a) STEELINE Flat Trusses and Roof Deck ☐ Width________
(b) STEELINE Pitched Roof Systems ☐ Length________
(c) Complete STEELINE Buildings ☐ Height________

Name________________________
Firm________________________
Address________________________

CAREW STEEL PRODUCTS CORPORATION • YORK, PA.



Shunk

GRADER AND SCARIFIER BLADES

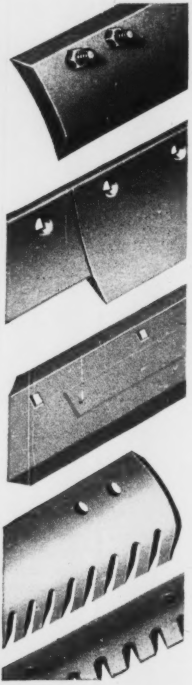
For any type or make of machine—Motor Graders, Maintainers, Scrapers, Drags, Bulldozers, Backfillers, Wagon Scrapers, Trail Builders, Trail Blazers, Carryalls, Snow Plows. Also—CUTTING EDGES, WEARING BOOTS, BACK SLOPERS, EXTENSION BLADES, MOLDBOARDS and SCARIFIER TEETH

50 years of specializing in the manufacture of Construction Equipment Blades has developed for your benefit a quality of special steel, milled through our own rolls and forged at the edges to give that extra cutting and wearing quality you need.

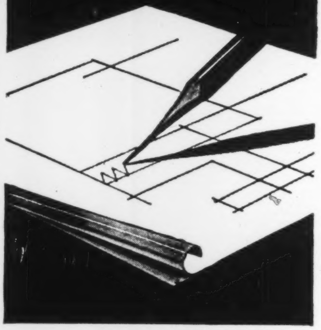
Furnished in various widths, lengths, and thicknesses, punched ready to fit your machine.

Consult your internationally recognized Blade Specialists. Write for special bulletins, giving type and name of machines you operate—get set for Blades early.

Shunk
MANUFACTURING COMPANY
Established 1854
BUCYRUS, OHIO



TRACING CLOTH for HARD PENCILS



● Imperial Pencil Tracing Cloth has the same superbly uniform cloth foundation and transparency as the world famous Imperial Tracing Cloth. But it is distinguished by its special dull drawing surface, on which hard pencils can be used, giving clean, sharp, opaque, non-smudging lines.

Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

Imperial Pencil Tracing Cloth is right for ink drawings as well.

IMPERIAL PENCIL TRACING CLOTH

SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE.

Look to OSGOOD . . .

FOR
PROFITABLE PERFORMANCE
AND
ECONOMY OF OPERATION

A Complete Line of **DRAGLINES, POWER SHOVELS, CRANES, BACKHOES, PILE DRIVERS**
Crawler and Pneumatic-Tire Mounted
Diesel, Gas, Electric, 3/8 to 2 1/2 Cu. Yd.

There are a number of important, time-saving and money-making features built into every Osgood unit—complete *Air Control* of basic motions; an *Air Cushion Clutch* that provides top speed almost instantly, without lag, without grab or jerk; adjustable *Hook Rollers,* operating on the underside of the rotating gear to keep the upper body stabilized on the crawler truck frame . . . fewer wearing parts, greater accessibility of machinery, larger diameter power-operated frictions, and many similar advancements.

Look to Osgood for cranes, shovels, draglines, backhoes, and pile drivers that will give you more work every day, better performance, longer life, larger profits!

POWER SHOVELS • CRANES • DRAGLINES • CLAMSHELLS • BACKHOES • PILE DRIVERS

THE OSGOOD CO. O-G **THE GENERAL CO.**
EXCAVATOR
MARION OHIO

DIESEL, GASOLINE OR ELECTRIC POWERED • 3/8 TO 2 1/2 CU. YD. • CRAWLERS & MOBILCRANES

HERLIHY MID-
ENGINEERS AND

Organized in 1924, our first major project was the construction of Wacker Drive in Chicago. We are proud of our accomplishments during the past twenty-five years, and look forward with confidence and optimism to the future.

Congratulations to Engineering News-Record on 75 years of service to engineers and contractors.

Electric Generating Plants
Transmission Lines and Substations
Subways and Tunnels
Industrial Plants
Heavy Railroad Construction, Bridges, and Trackwork
Bridges, Viaducts, and Grade Separations
Sewage Disposal Plants
Caissons and Building Foundations
Institutional Buildings

•

. . . THEN

WACKER DRIVE CONSTRUCTION

NOW . . .

WO-1212.1-16
7-6-49

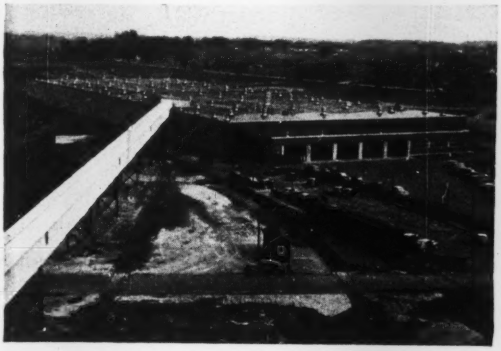
Above:—
WACKER DRIVE CONSTRUCTION
MARCH 1926

•

Right:—
WACKER DRIVE EXTENSION
JULY 1949

CONTINENT COMPANY

CONSTRUCTORS



FINISHED GOODS WAREHOUSE, Kellogg Company, Battle Creek, Michigan (loading capacity 36 cars at one time)

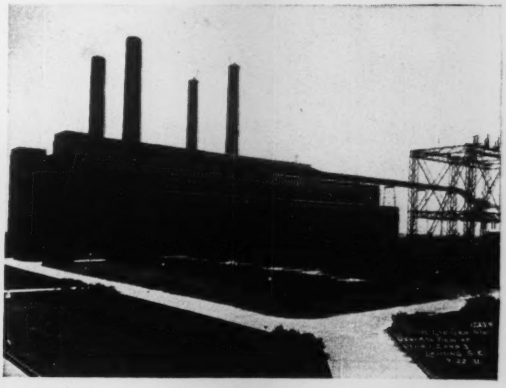
SUBWAY (twin tube at Chicago Avenue Station) Chicago, Illinois

HERLIHY

MID-CONTINENT COMPANY

Chicago, Illinois

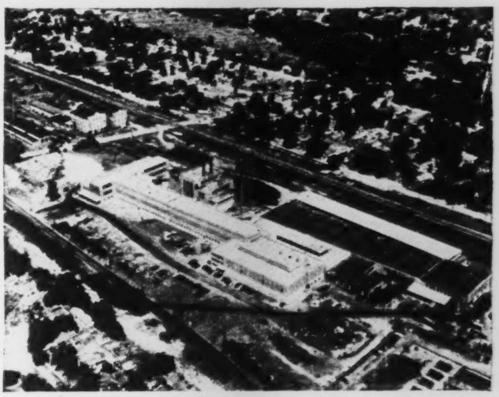
MEMBER AGC



STATE LINE GENERATING STATION, Chicago District Electric Generating Company, Hammond, Indiana

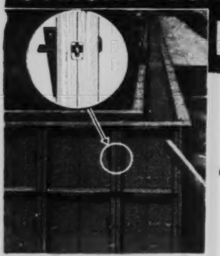
24472
10-20-38

SOUTHWEST SEWAGE DISPOSAL PLANT, Division A, Sanitary District of Chicago (400 m. g. d. by activated sludge process, producing 90 per cent removal of B. O. D. and suspended solids)



BOARD MILL (300-ton capacity), Michigan Carton Company, Battle Creek, Michigan

SYMONS CONCRETE FORMS



Your answer to low foundation costs

Here's Why!

Symons Concrete forms save you 50 to 75% of the entire labor of forming. You eliminate eleven costly steps in concrete form construction, and the following materials:

- √ Nails
- √ Lumber for more than one waler
- √ Most of the lumber for bracing
- √ Loss of lumber caused by the splitting action of nails
- √ Spreaders

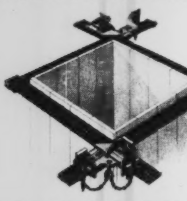
These forms can be built in your own shop . . . saving you freight . . . or you may purchase the forms complete.

Inset shows head on view of tie.

At left is cross section view of tie.

SAFETY SHORES and "Ever-Square" COLUMN CLAMPS

. . . . the builders choice



"EVER-SQUARE" COLUMN CLAMPS . . . with one piece, 90 degree angle bracket which positively squares up column. Adjustable to smallest fraction. No detachable parts. Bars of alloy steel, corner brackets of malleable iron.

ADJUSTABLE SAFETY SHORES . . . Light in weight, easy to adjust, no instructions are needed and they have greater load capacity. The lifting jack lifts like hydraulic. Malleable castings.

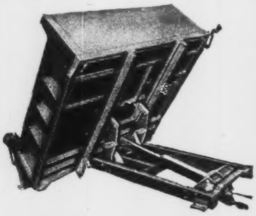
Symons Concrete Forms, Safety Shores and Column Clamps can be rented with 90-day purchase option. Paid rentals apply on purchase price. Write today for complete details and prices

SYMONS CLAMP & MFG. Company
4265 W. Diversey Ave.
CHICAGO 39, ILLINOIS

"I BOUGHT ANTHONY DUMP BODIES— —THEY COST ME LESS"

Contractors everywhere are buying where they can do the best. As one contractor recently remarked:

"After weighing all of today's factors of price, quality, and performance I bought Anthony Dump Bodies and Hoists . . . they cost me less."



For prices on equipment to meet your specifications it will pay you to call your Anthony distributor. Quick delivery from stock. Write for name of your distributor.

ANTHONY CO, Streator, Ill. ANTHONY HYDRAULIC

FLEXCO HD BELT FASTENERS AND RIP PLATES

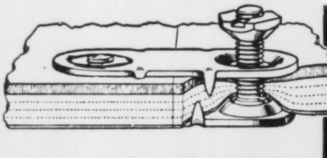
FOR HEAVY CONVEYOR AND ELEVATOR BELTS OF ANY WIDTH

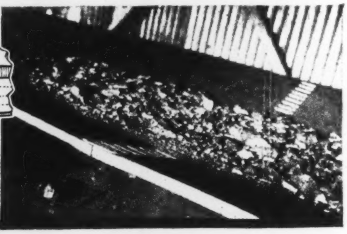
Flexco HD Fasteners make a tight, butt joint of great strength and durability . . . distribute the strain uniformly. Operate smoothly over flat, crowned or take-up pulleys. Made of steel, Monel, Everdur and Promal.

Flexco Rip Plates are for repairing and patching damaged belts.

Ask for Bulletin F-100

FLEXIBLE STEEL LACING COMPANY • 4656 Lexington St., Chicago 44, Illinois





Strong, Smooth, Readily Troughing
Order From Your Supply House

Metropolitan Life's Stuyvesant Town and Peter Cooper Village—park-like residential communities in the heart of New York—contain 11,250 modern apartments.

Metropolitan Life's Riverton transforms a hitherto run-down section of Harlem into an attractive residential neighborhood which will accommodate about 3,500 people in 1,232 modern apartments.

NATIONAL TUBE CO.

More "NATIONAL" landmarks

Over 4½ million pounds of NATIONAL Pipe are used to safeguard the heating systems of New York's three greatest Land Redevelopment Projects.

In Metropolitan Life's Stuyvesant Town, Peter Cooper Village and Riverton, 2,274 tons of National Standard Black and Galvanized Pipe have been installed to serve the 35,000 fortunate tenants of these beautiful new apartment buildings that now replace the ugly flats and squalid structures of former "gas-house" districts.

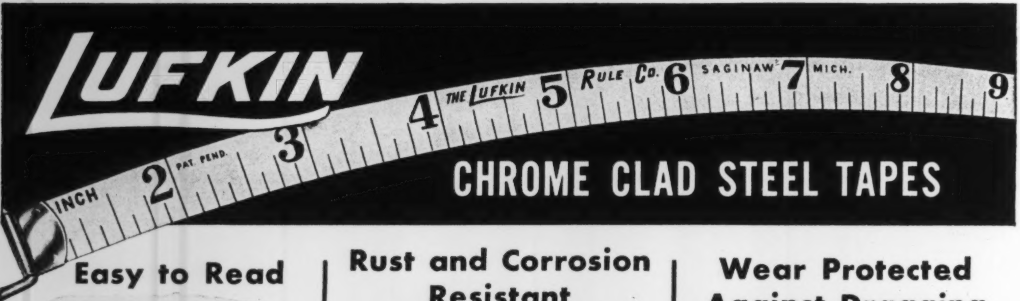
The selection of enormous quantities of National Pipe for these modern buildings is another tribute to the high reputation that this service-tested pipe enjoys among the men who design, supervise and construct and who control buying and specifying of construction products.

National Pipe has earned its widespread preference not because it is produced by the world's largest maker of tubular products but because for more than half a century National Pipe has proved that it gives *most service per dollar of cost.* There's no better basis for selecting pipe than this. We believe it's the reason why more National Pipe is in use in America than any other kind.

NATIONAL TUBE COMPANY, PITTSBURGH, PA.
COLUMBIA STEEL COMPANY, SAN FRANCISCO,
PACIFIC COAST DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

NATIONAL Steel PIPE

UNITED STATES STEEL



CHROME CLAD STEEL TAPES

Easy to Read

in sun . . .

Special non-glare satin finish on heavy chrome plating that adds to toughness of the line. Durable jet-black markings stand out sharply against this light-absorbing surface. Will not crack, chip or peel.

Rust and Corrosion Resistant

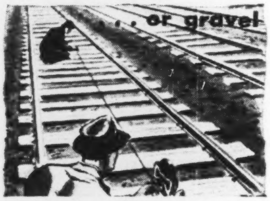
in tropical damp . . .

. . . or chemical fumes

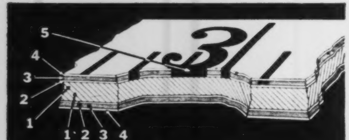
A rust-resistant coating plus *multiple* coats of electroplating give remarkable protection against rust and corrosion under conditions no other tapes can withstand.

Wear Protected Against Dragging

on concrete . . .



Markings are bonded to the steel base, and are sunk *below* the chrome surface to protect against wear. No metal is etched away. Hardened steel tape—tough—flexible—kink-resistant—protects against line breakage.



DIAGRAMMATIC CROSS-SECTION VIEW

1. Hardened Steel Tape. 2. Rust-Resistant Coating. 3. Multiple Coats of Electroplating. 4. Hard, Smooth, Non-Glare Chrome-Plating. 5. Black Markings Bonded to Steel, Sunk below Surface.

The instant you pick up a Lufkin Chrome Clad Steel Tape, your hands and eyes will approve it. You will like the satin-smooth flexible "feel"—the precision-made appearance—the easy-on-the-eyes finish and markings.

But only usage—the rougher the better—will prove how and why Chrome Clad Steel Tapes actually *do* what no other tapes *can* do.

Use them in extremes of noon-day sun or tunnel shade and you'll be surprised how plainly the markings stand out—with less stooping, squinting and eye strain.

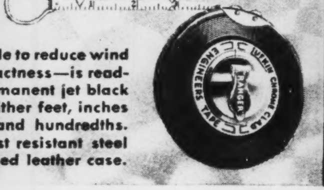
On gruelling construction work, you'll find kinking and line breakage rare indeed and the markings still sharp after years of usage.

Or test them in mines, oil fields, chemical plants or sea water and their amazing rust and corrosion resistance will delight you.

Call for Lufkin Chrome Clad Steel Tapes at your dealers and prove these statements for yourself.

Buy steel tapes with easy-to-read markings that are durable

"RANGER" Model . . . Lufkin's Chrome Clad tape specially designed for engineers. The sturdy steel line—only 1/4" wide to reduce wind resistance and provide compactness—is readily detachable from case. Permanent jet black markings are available in either feet, inches and eighths or feet, tenths and hundredths. Zero falls at end of line. Rust resistant steel liner protected by hand stitched leather case.



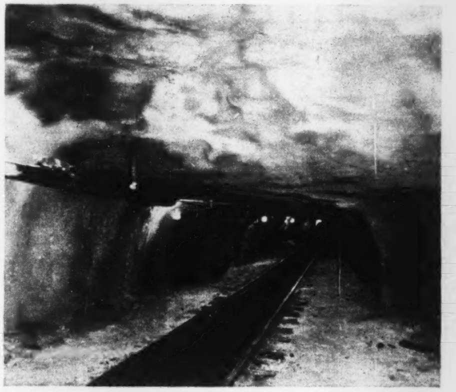
Buy LUFKIN

PRECISION TOOLS • TAPES • RULES
FROM YOUR DISTRIBUTOR

THE LUFKIN RULE CO.

Saginaw, Michigan • New York City • Windsor, Canada

GUNITE *"Shot with air"* *Specialists since 1922*



YOUR dollars can buy the finest skill in applying "GUNITE" for construction and in maintenance. This is due to our long experience which is most important in this type of work. We are prepared to undertake the largest jobs and begin work immediately. "GUNITE" is your economical answer. Our clients profit from our experience.

"GUNITE" was applied to the main haulways and air shaft at Enoco Mine, Bruceville, Indiana for the Enoco Collieries. This modernization now affords better working conditions and assures a greater measure of safety.

- *We solicit your inquiries*

INDIANA GUNITE & CONSTRUCTION CO., Inc.
226 NORTH ALABAMA STREET INDIANAPOLIS, ALABAMA

THE
KINNEY PUMP
MAKES THE
BIG DIFFERENCE

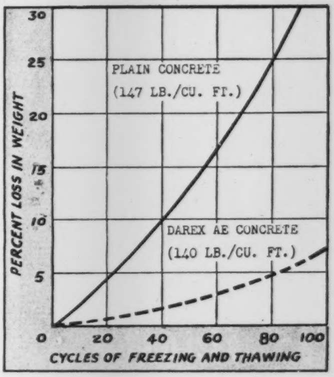
Whether handling oils, tars, asphalts, or emulsions, you can count on a Kinney Bituminous Distributor to give the smooth, uniform coverage called for in road, highway, and airport construction. Only this Distributor has the Kinney Rotating Plunger Pump — your assurance of precision bitumen application. Heated by hot engine exhaust, the pump is ready to go at all times. It delivers up to 405 GPM in a steady, non-pulsating flow and with meter-like accuracy. Simple controls and improved spray bars, spray nozzles, and heating system combine to make the Kinney Distributor easy to operate and 100% dependable. The Fraco Circulating Hot Spray Bar can be furnished if desired. Write for Bulletin A-48.

KINNEY
BITUMINOUS
DISTRIBUTOR

KINNEY MANUFACTURING CO.
3527 Washington Street, Boston 30, Mass.
New York • Chicago • Cleveland • Philadelphia
New Orleans • Houston • Los Angeles • Seattle
San Francisco

We also manufacture Liquid Pumps, Vacuum Pumps, and Clutches.

For Durable Concrete Use Controlled Air with DAREX AEA



In accelerated lab tests, plain concrete (solid line) lost 5% of its weight through spalling after 22 cycles of freezing and thawing in the presence of calcium chloride. In concurrent tests, DAREX Air Entrained concrete required 83 cycles to lose 5% — an increase in durability of nearly 400%.

Field experience with millions of yards of DAREX A E concrete *controlled* for air content, strength and durability substantiates laboratory findings. Here is insurance that concrete life is doubled, trebled, even more.

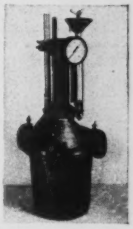
Conventional job insurance expires on completion of the job, but *this* is extended job insurance, and insurance on your reputation for life.

Controlled air does just that. And at no expense because the cost of DAREX AEA (air entraining agent) is usually more than offset by savings in the fine aggregate alone.

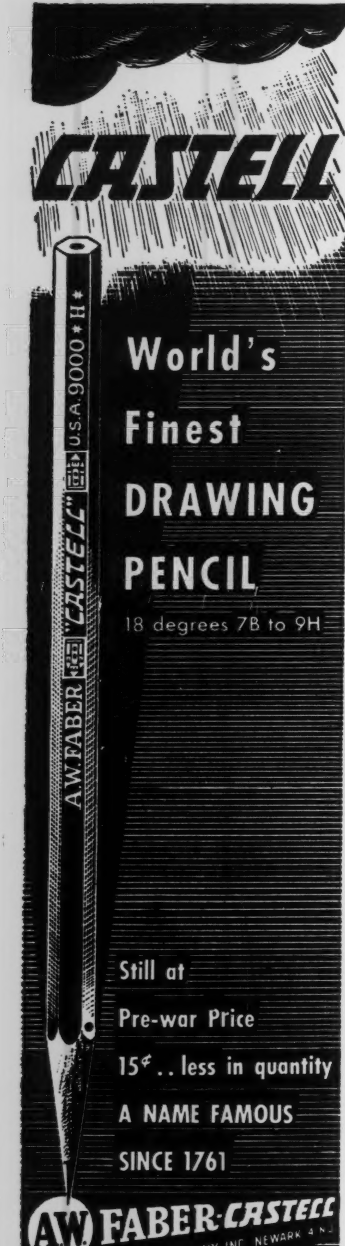
Figure DAREX AEA into your next job.

DAREX AEA

Inexpensive air meters are available to give you complete control at the mixer



Cement Division
DEWEY AND ALMY CHEMICAL CO.
Cambridge 40, Massachusetts



World's Finest DRAWING PENCIL

18 degrees 7B to 9H

Still at Pre-war Price

15¢ .. less in quantity

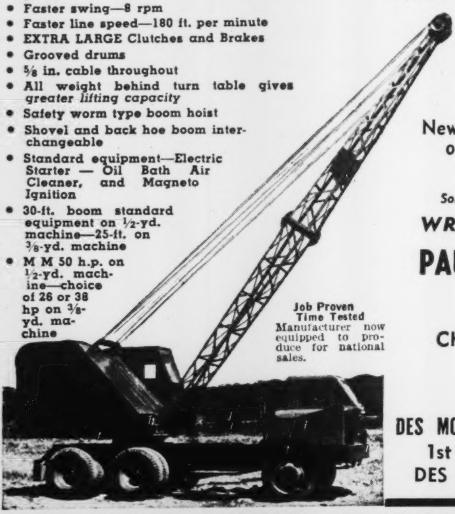
A NAME FAMOUS SINCE 1761

A.W. FABER-CASTELL
PENCIL COMPANY INC. NEWARK 4 N.J.

Nothing Rolls like a Ball . . .

Exclusive Features

- Ball bearing turn tables (358 one-inch balls) "Patented"
- Lower mounting—from 6 to 7" lower
- Less maintenance cost. Simplicity of design — for example, complete interchange of gears, clutches, and brakes this means minimum inventory of spare parts
- Faster swing—8 rpm
- Faster line speed—180 ft. per minute
- EXTRA LARGE Clutches and Brakes
- Grooved drums
- 5/8 in. cable throughout
- All weight behind turn table gives *greater lifting capacity*
- Safety worm type boom hoist
- Shovel and back hoe boom interchangeable
- Standard equipment—Electric Starter — Oil Bath Air Cleaner, and Magneto Ignition
- 30-ft. boom standard equipment on 1/2-yd. machine—25-ft. on 3/8-yd. machine
- M M 50 h.p. on 1/2-yd. machine—choice of 26 or 38 hp on 3/8-yd. machine



Job Proven
Time Tested
Manufacturer now equipped to produce for national sales.

LITTLE ● GIANT
CRANES & SHOVELS

Patented Turntable

Full 3/8 and 1/2 yd. Truck Mount

No Center Pin
No Hook Rollers

•

Priced to sell
in today's Market

New Carrier for both sizes
or use your own truck

•

Some Dealer Franchises Available

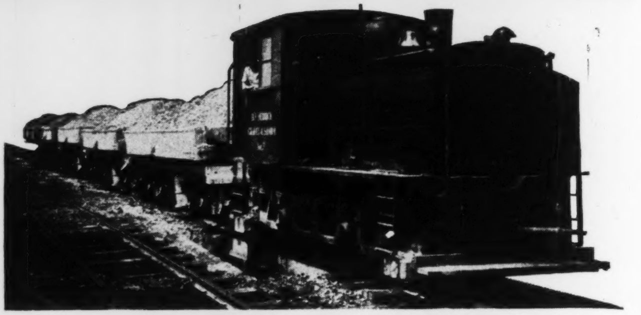
WRITE

PAUL M. COLE CO.
National Distributor
30 N. LA SALLE ST.
CHICAGO 2, ILLINOIS

•

Manufactured by
DES MOINES DRAGLINE SERVICE
1st and Pinehill Drive
DES MOINES 13, IOWA

MEN Who Know Equipment SPECIFY
PLYMOUTH Locomotives



Over a period of many years, under all kinds of operating conditions, PLYMOUTH Locomotives have established proved records of dependable performance. Economical to use and economical to maintain, PLYMOUTH Locomotives are built well — and built right — by careful engineering planned to meet exacting requirements in the construction field. We feel sure there's a PLYMOUTH Locomotive to meet your particular needs. Write for complete details today.

FOR COMPLETE DETAILS WRITE TODAY
PLYMOUTH LOCOMOTIVE WORKS
DEPT. A-4
PLYMOUTH, OHIO

A Contractors Building if you ever saw one

As a contractor you probably have pretty definite ideas on the kind of building you need for your own use. Let's see how ARMCO STEELOX Buildings meet these requirements.

Here is a sturdy, dependable building that provides all the advantages you would normally expect in any permanent structure. But the unique construction also makes it ideal for use on temporary sites.

ARMCO STEELOX Buildings are easily and quickly moved. They retain structural strength and weathertightness even when dismantled and re-assembled many times. Obsolescence is never a problem. A STEELOX Building can be quickly extended with standard parts. Loosening a few bolts and re-arranging the panels permit changing doors and windows.

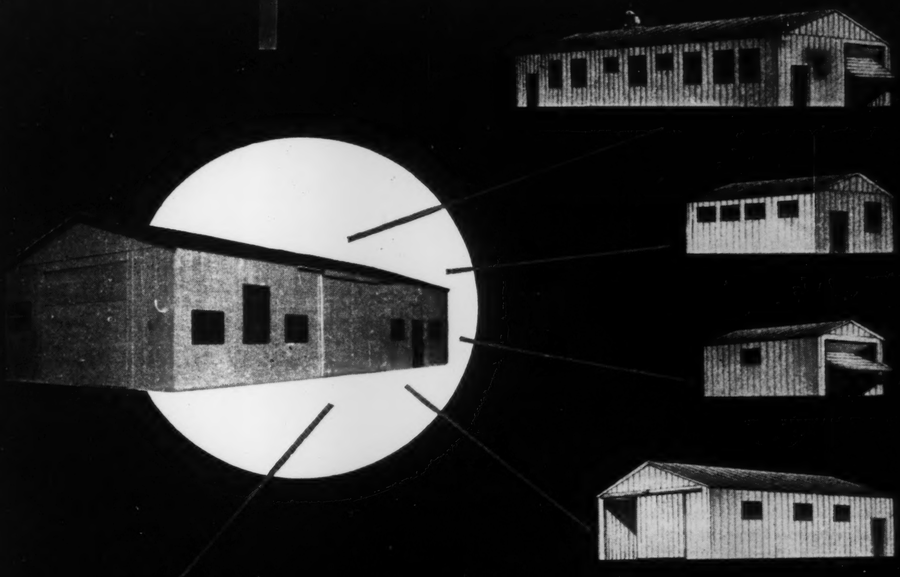
You'll also appreciate how easily and quickly STEELOX Buildings can be erected. The STEELOX Section provides both structural support and finished surface. On the roof it replaces rafters, sheathing and roofing. For sidewalls it eliminates framing and exterior covering.

There is a size and type of Standard ARMCO STEELOX Building for almost every contracting need, and delivery when you need it. Write for complete information. Armco Drainage & Metal Products, Inc., 2355 Curtis Street, Middletown, Ohio. Export: The Armco International Corporation.

STEELOX Timetable

Actual case history shows how one owner moved a Standard STEELOX Building (12′ x 32′ x 8′) to a new site using only 5 men and a truck.

7:00-10:30 A. M.—*Dismantled building and loaded on truck.*
10:30-11:00 A. M.—*Driving to new site.*
11:00-11:30 A. M.—*Lunch.*
11:30- 7:00 P. M.—*Building completely re-erected and ready for use.*
Only a total of 55 man-hours required for complete move.



ARMCO

ARMCO STEELOX BUILDINGS

Permanent or Field Offices • Garages • Drafting Rooms • Warehouses
Shops • Boiler Houses • Watchmen Shelters • Bunk Houses and Others

STANG WELLPOINTS

Engineering News-Record
July 7, 1949

Wellpoints Dry Morelos Dam Excavation

Some 3800 STANG WELLPOINTS and 45 STANG PUMPS

were required to keep the Colorado River from seeping into excavations 45 to 50 ft. below river surface on the first-stage construction of Morelos Dam. The well-point system included three main stages and a supplementary fourth stage at a lower elevation. Stages one and two completely enclosed the excavated area; stage three formed a complete circle around the location of the deepest excavation (18.3 m.) but did not enclose the entire 15-acre site. Additional wellpoints were installed downstream from the main cofferdam, in subsidiary excavations required for placing riprap on the side of existing levees and along the bottom of a channel next to the dikes.

These two recent STANG jobs are ONLY two of hundreds of large and small DRYING jobs that STANG has successfully handled during the past few years. More and more Engineers and Contractors are turning to STANG for the Know-how and facilities to solve the problems of wet jobs on ALL types of construction work. STANG Engineers are at your service to dry your job—anywhere.

JOHN W. STANG

2 Broadway
2123 S. 56th St.,Omaha, Nebr.

are making HISTORY

Engineering News-Record
July 14, 1949

Davis Dam Fill made in Record Time

Among the many other big jobs using STANG Wellpoints are:

DAMS:	Cedar Bluffs, Kansas Dickinson, Nebraska Enders, Nebraska Harlan County, Nebraska Heart Butte, North Dakota Medicine Creek, Nebraska
POWER HOUSES:	Iowa Power & Light Co. Kansas City Power & Light Co. Pacific Gas & Electric Co. Southern California Edison Co. San Diego Gas & Electric Co.
SEWERS:	Dallas, Texas Long Beach, California Oklahoma City, Oklahoma Hyperian Beach, California Texas City, Texas

Some 3300 STANG WELLPOINTS used at DAVIS DAM SITE

Ten months from river diversion to completion of the fill is the record made by the Utah Construction Company on the 3,670,000-cu.yd. earth-and-rock-fill for Davis Dam on the Colorado River. Involved were: Excavation of a 55-ft. deep cutoff trench, installation of 2,400 STANG wellpoints in the dam foundation and 900 more to develop the tailrace area. Water was lifted from below the bottom of the cut-off trench almost 100 feet. Servicing the wellpoints in the cut-off trench were 22 10″ and 5 8″ pumps. Maximum pumping rate was 12,000 gph.

CORPORATION
New York 4, N. Y.
8221 Atlantic Ave., P.O. Box 631, Bell, Cal.

A Mechanical Policeman!

DAVENPORT
AUTOMATIC
BOOM-STOP

U. S. Pat. No. 2393312
Canada Pat. No. 438536

Prevent serious and costly accidents to men and equipment

You lose hundreds of dollars a day when a rig is laid up for repairs . . . that's why we say equip your rigs with the Davenport Automatic Boom Stop—the *cheapest insurance* you can get for those unavoidable accidents which occur when the boom is raised to a dangerous elevation. Your own mechanic can install it—in less than 2 hours—to the cab frame, directly in line with the boom so that the boom will lift the trigger that throws out master clutch if raised beyond safe limits. There is no delay in operation AFTER the Boom-Stop has PREVENTED an accident. You can't afford not to have this protection if you have men and equipment in your care. Let us send descriptive booklet which gives many important facts.

action instantaneous and foolproof

•

nothing to service nor replace

•

costs little—saves much

•

easy to install

•

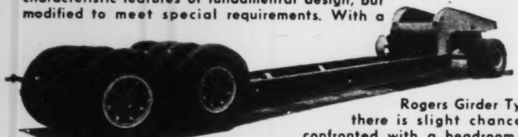
functions as long as the rig

DAVENPORT EVER-READY BOOM STOP CO.
MOUNTAIN HOME, ARKANSAS

"LOW BRIDGE AHEAD"
ROGERS
HEAVY DUTY
Governed Trailers

the answer to that problem is this
ROGERS GIRDER-TYPE TRAILER

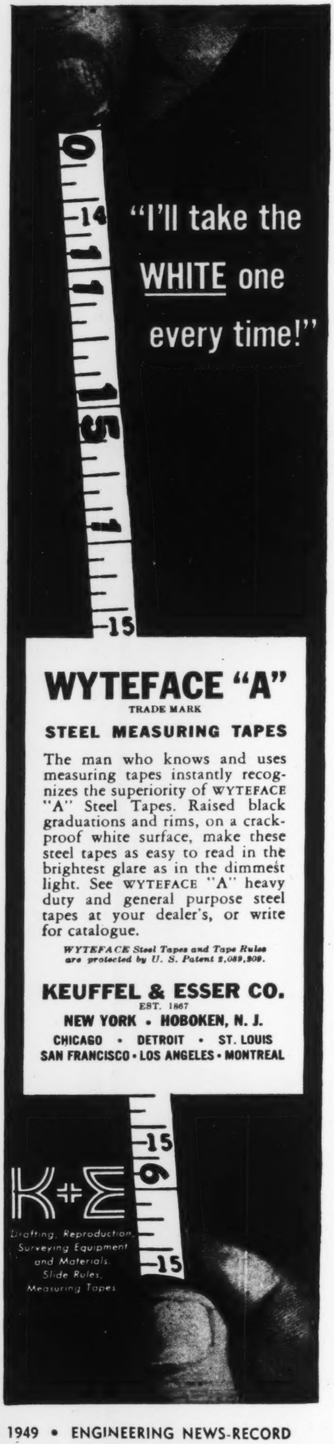
Rogers builds trailers for unusual needs, embodying characteristic features of fundamental design, but modified to meet special requirements. With a Rogers Girder Type Trailer there is slight chance of being confronted with a headroom clearance problem. Special construction affords an unusually low bed.



ROGERS BROTHERS CORPORATION
135 ORCHARD ST. ALBION, PA.

ROGERS TRAILERS
EXPERIENCE *builds 'em* • **PERFORMANCE** *sells 'em*

Export Address: 50 Church St., N. Y. 7, N. Y. Cable Address "Broscites"


"I'll take the WHITE one every time!"
K+E
Drafting, Reproduction, Surveying Equipment and Materials, Slide Rules, Measuring Tapes

WYTEFACE "A"
TRADE MARK
STEEL MEASURING TAPES

The man who knows and uses measuring tapes instantly recognizes the superiority of WYTEFACE "A" Steel Tapes. Raised black graduations and rims, on a crack-proof white surface, make these steel tapes as easy to read in the brightest glare as in the dimmest light. See WYTEFACE "A" heavy duty and general purpose steel tapes at your dealer's, or write for catalogue.

WYTEFACE Steel Tapes and Tape Rules are protected by U. S. Patent 2,089,209.

KEUFFEL & ESSER CO.
EST. 1867
NEW YORK • HOBOKEN, N. J.
CHICAGO • DETROIT • ST. LOUIS
SAN FRANCISCO • LOS ANGELES • MONTREAL

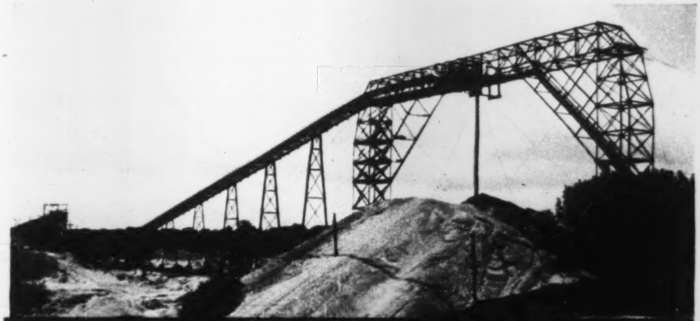
★★★★ **Barber-Greene** ★★★★

PRTD. IN U. S. A.

B-G COST-SAVING BULLETIN No. 4906

145M-AM-8-49

B-G PERFORMANCE PAYS DIVIDENDS TO USERS IN MATERIAL HANDLING, ASPHALT CONSTRUCTION AND DITCHING



B-G Conveyors operated by McGrath Sand and Gravel Co., to maintain a 15,000 ton surge stock pile at their Pekin, Ill., plant.

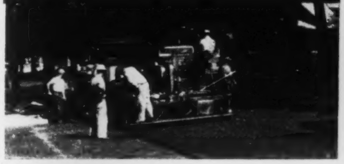
Concrete Resurfacing "Big Business" for Owners of B-G Asphalt Equipment

Abilene, Kan.: Typical of the many contractors who have been keeping their B-G Asphalt Equipment profitably busy on resurfacing jobs, the Reno Construction Co. of Kansas has recently completed a project between Abilene and Chapman on U. S. Route 40.

This important highway—18 feet wide and most of it around twenty-five years old—had disintegrated to the point where further maintenance was not justified. The contractor removed those areas which were beyond salvage, repaired or replaced the base material and relaid the concrete slab. A 24-inch bituminous concrete extension was laid on either side, and then the Barber-Greenes went to work.

Reno Construction Company's B-G 848 high-capacity Asphalt Plant—with Gradation Unit, Dryer and Dust Collector—produced 100 tons of asphalt cement mix, hour after hour.

B-G high capacity Bituminous Mixing Plants such as this are highly portable, easy to erect, accurate and simple in operation.



849269

B-G Tamping-leveling Finisher lays a smooth, level surface regardless of variations in the sub-grade.

Runabout Ditcher "Does Work of Three Crawler Machines"

843535

A large southern gas, light and water company reports that its B-G Runabout Ditcher has proved itself the "equal of three crawler-mounted machines in daily output." This pneumatic-tired ditcher is highly portable, travels under its own power. The company further reports, "the Runabout is ideal for laying small mains and services . . . in installing services across a black top street we allow traffic to cross the ditch without the aid of planks or bridges, since the ditch is only 6 inches wide.

"B-G CONVEYORS ARE REALLY ENGINEERED"

Pekin, Ill.: Impressive evidence of the adaptability and flexibility of B-G Permanent Conveyors is presented in the local plant owned by the McGrath Sand and Gravel Co. Of their two standard "off the shelf" B-G Conveyors already operating—and a third, which is gradually replacing a twenty-year-old structure—R. H. Ashley, Superintendent, has this to say: "We like them; they are easy to erect, and fit into our operations nicely. They even *look* good—as if they have been engineered for the job."

At the Pekin plant, river sand is excavated by dredge and delivered to a crusher. Here a B-G Conveyor takes the material skyward in a spectacular rise to a discharge point in the center of an overhead bridge structure. (See photo at left.) This bridge permits the building of a 15,000 ton surge stock pile which makes dredging and plant operations independent of each other.

A tunnel conveyor underneath the pile carries material to a wood frame conveyor—being replaced a span at a time by B-G Conveyor sections—leading to the main plant.

847590

B-G 92 Car Unloader with 661 Gooseneck Conveyor.

"A Pleasure to Recommend B-G Equipment"

Asheville, N. C.: After Community Coal and Lumber Co. changed from hand unloading to mechanized B-G unloading of coal from railroad cars, their man-hour requirements were cut 66% while capacity of cars handled was doubled. With a B-G 92 Car Unloader and 661 Gooseneck Conveyor, one man now does the whole job. J. E. Divelbiss, Jr. of the Company further states, "We have been highly pleased with B-G Equipment—had very low maintenance. It is a pleasure to recommend Barber-Greene to anyone in this business."

B-G BUCKET LOADER PAYS FOR ITSELF SEVERAL TIMES OVER

846644

B-G Model 522 Swivel Conveyor Bucket Loader operated by William Schwante & Sons, Chicago.

Cuts Man-Hours, Speeds Up Loading for this Material Yard

Chicago, Ill.: Since 1946, when purchased by William Schwante & Sons, a B-G 522 Swivel Conveyor Bucket Loader has paid for itself many times over by its savings in manpower alone. Further, in loading sand, gravel, stone and stoker coal at full capacity, the 522 has cut truck time to the bone—and its versatility, speed and portability have made it one of the most valuable machines in the yard. As Mr. Schwante puts it, "I can load a truck of stoker coal in practically nothing flat." He goes on to say that in the past three years repairs on his B-G 522 have been "next to nothing." Here again the widely useful pneumatic-tired 522 Loader proves that you can't beat B-G mechanized loading of free-flowing material.

Johnstown, N. Y.: By adapting their B-G 522 Bucket Loader to snow handling (with the B-G low cost snow flight line) the city of Johnstown, New York, has gained year-round use of their loader. In summer, sand and stone for paving operations are loaded. For winter service, the change is made and the loader clears windrowed snow from the city streets—loading a truck in a few minutes where before 4 to 6 men took half an hour for the same job.

"Big Brother" to the B-G 522 Loader, the 545A is a heavy-duty 3 cubic yard per minute, self-propelled machine.

848369

At top capacity, stoker coal is reclaimed to truck with a B-G 672 Coal Loader at Fidelity Mines' radial layout.

B-G Radial Layout Speeds Truck Loading at Illinois Strip Mine

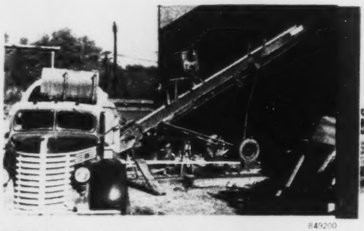
DuQuoin, Illinois: At the Fidelity Mine of the United Electric Coal Co., near DuQuoin, Ill., a completely equipped Barber-Greene radial coal handling layout with car unloader, stacker-conveyor and two self-propelled reclaiming coal loaders has considerably speeded up truck loading operations.

Once sized, cleaned and classified, the coal is delivered to the radial installation in hopper bottom cars. There it is unloaded with a B-G Model 93 pit car unloader and a radial-mounted, swivel wheel B-G flight type stacker conveyor.

Reclaiming into trucks of various sizes is done with either a Barber-Greene Model 672 cleated belt conveyor or a B-G power propelled Model 661 "Gooseneck" flight conveyor. Although nominally rated at 2 tons per minute, the 672, when loading stoker coal into large semi-trailer trucks, consistently handles up to 3 tons per minute. For larger sizes of lump coal, the "Gooseneck" 661 is employed, with its adjustable discharge permitting low drop into truck, preventing costly breakage.

The widely used, well-integrated B-G radial layout is proving itself an important time and labor saver when truck distribution of coal is desirable.

USERS FIND LOWEST COST WAY TO DO MANY JOBS IS WITH B-G PORTABLE CONVEYORS



849200

B-G Portable conveyor delivering concrete to second floor from transit mixers.

Speeds Concrete Placement

Alton, Ill.: Pouring concrete seats for a stadium, pouring walls and recently, pouring the second floor on a factory remodeling job—this is the class of work that has been turned over to a B-G Portable Conveyor by R&R Construction Company. On this latter job, the conveyor operated at a 30° incline, was started and stopped frequently with a full load on the belt without stalling. On job after job the versatile Barber-Greene has eliminated the need for a concrete elevator and has saved many dollars in time and labor in getting concrete into the forms.

847182

A B-G Belt Car Unloader, Portable Conveyor and Bucket Loader team up on this job.

Eliminate Truck Crane

Winnetka, Ill.: Unloading hopper-bottom cars of sand and gravel with a rented truck crane is an unsatisfactory operation—too costly, too slow—as discovered by Weissenberg Fuel Company of this town. With the purchase of a B-G 358 non-slip chain and belt car unloader and a B-G Portable Conveyor the company eliminated this expensive practice. This B-G team now unloads material in half the time and conveys it swiftly to the stock piles. It's a one-man operation—no high truck crane rental.

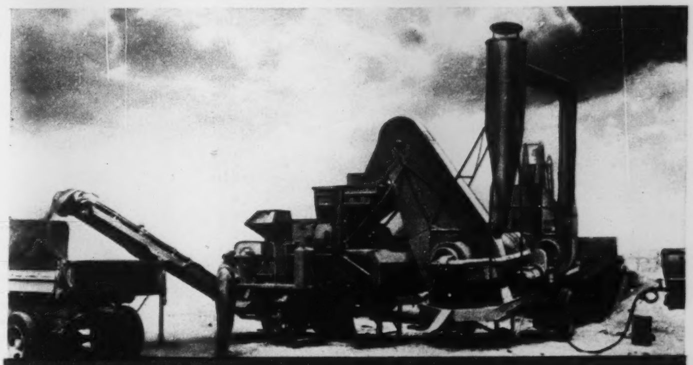
THREE B-G PLANTS MAKE POSSIBLE YEAR 'ROUND MAINTENANCE OF SOUTH DAKOTA ROADS

Operate Efficiently in Freezing Weather

Pierre, S. D.: Three B-G Maintenance Asphalt Plants are solving the problem of early spring road repair for the State Highway Department. Until now, early work has been seriously hampered by frequent freezing rains that made blade mixing impossible and delayed vital spring repairs.

Delivered in December, the plants were sent to Huron, Rapid City and Aberdeen. Each was set up in less than two days despite sub-zero temperatures. The Huron and Aberdeen plants went to work at once, producing a quality mix and providing maintenance crews with all the material required to maintain roads in good condition.

All plants are used to stockpile excess material close to the plant site during slack periods for future reclaiming as needed. The slow curing qualities of the bituminous mix produced for stockpiling make it possible to anticipate summer requirements—and to keep the plants usefully and economically at work practically the year 'round.



Each of these [illegible]

B-G DITCHER DIGS IN CENTER OF HIGHWAY FOR CONDUIT INSTALLATION

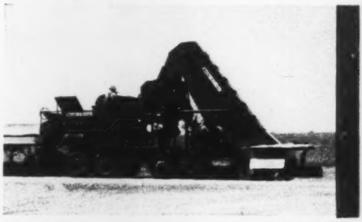
848274

B-G 44C Ditcher digging 24-inch by 4-foot conduit trench on busy concrete street.

Milwaukee, Wis.: Digging a 24-inch conduit trench down the center of a concrete highway and over numerous uncharted obstructions is the latest of many impressive performances of Stone Construction Company's B-G 44C Ditcher.

Here, concrete was broken up with jackhammers and removed for a path wide enough for the ditcher boom. The B-G automatic overload release prevented damage to both machine and pavement whenever, by chance, the bucket line came in contact with the concrete. Further, the ability of the B-G Vertical Boom to dig straight down, leaving no ramp, saved untold hours of hand digging: the 44C dug right up to underground obstructions.

Because the conduit was a foot or more thick, excessive backfill could have been a problem. The 44C loaded much of the material directly into trucks.

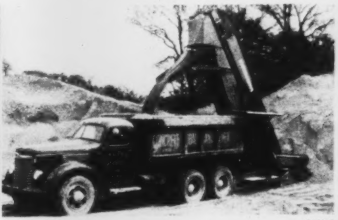


848548

The B-G Travel Plant offers lowest cost means of producing quality bituminous mixes.

Travel Plant Has Thousands of Miles Behind and Ahead of It

The B-G Travel Plant has for many years been identified with low cost, high quality bituminous roads. At minimum cost, it produces highest quality bituminous or stabilized "mixed in place" material. Consisting of two B-G units—the 848 Mixer which is towed and supplied by a B-G Paving Bucket Loader—the Travel Plant allows economical use of local materials. It does not obstruct traffic. Requires but two operators. Accurate proportioning saves asphalt and gives a uniformly finished job.



847498

The B-G 82A Crawler-mounted Loader is a heavy duty, 3 cubic yard per minute, sure-footed machine.

FAST LOADING, STRIPPING AND PICKUP WITH THIS B-G CRAWLER-MOUNTED LOADER

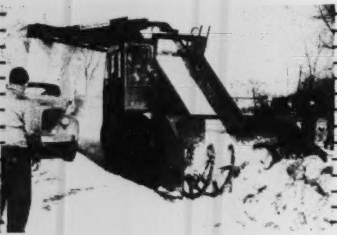
The husky, high capacity B-G 82A Loader has been setting records for output and versatility for years. On one job, two of these loaders excavated, screened and loaded 93,000 tons of bank-run gravel at a 1,000 tons per day clip. Another user reports 125,000 tons of sand handled by his 82A in two years with practically no repair cost. The 82A is a big high-discharge loader with all the B-G advantages—automatic overload release, floating boom, spiral feed, etc., ideal for the most severe service.

Ditcher Solves Problem with a New Slant to It

847397

***Castle Shannon, Pa.:* Alleyways too steep to be negotiated by automobiles—up to 15° slopes—were the site of a recent job done successfully by a B-G 720 Ditcher for Equitable Gas Company. Operating easily in the steep, narrow alleyways, the Barber-Greene often completed 4 or 5 blocks of such digging in half a working day—this despite numerous cross walks and extreme rocky conditions of the soil.**

SNOW OR CORAL ROCK "Barber-Greenes" CUT THE COST AND TIME REQUIRED TO MOVE IT


84852
B-G 548A Pneumatic-tired Snow Loader. Up to 20 cu. yds. per min. 7 m.p.h. road speed.

84937
B-G 522 Pneumatic-tired Snow Loader 5 cu. yds. per min. Convertible to bucket loader.

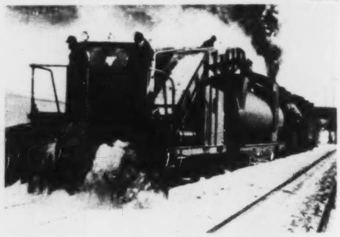
54321
B-G 710 Ditcher sets outstanding performance record on 100 mile coaxial cable job.

FAST CLEANUP OF CITY STREETS

B-G Snow Loaders have proved themselves throughout the "snow belt" as efficient, effective means of keeping city traffic moving, saving parking meter revenues and radically cutting the costs of snow removal. They offer benefits that can mean real savings to small towns as well as the largest cities.

B-G Snow Loaders provide fast, efficient snow removal service under the most severe conditions.

B-G Railroad Snow Loader-Melter. Clears yards, terminals, loading areas. Capacity, 30 cu. yds. per min.
848164



ROCK AND TREE STUMPS GIVE WAY TO B-G DITCHERS

Orlando, Fla.: Digging up to 1½ miles in a 4½ hr. working day—through stump-strewn coral rock—is the regular performance of two B-G 710 cable laying ditchers on this 100-mile coaxial cable job. The rapid saw-like action of the B-G Bucket line overcame the stump and rock problems. The cable is fed from a large reel and the ditchers tow backfilling plows which close the trench behind the cable.

FOR THE LATEST IN MATERIAL HANDLING, ASPHALT CONSTRUCTION OR DITCHING . . . USE THE COUPON

Complete specifications and literature are available on all the B-G equipment described in this bulletin. The coupon below makes it handy for you to quickly receive information which may lead to many cost-reducing improvements in your business operations. Look this bulletin over carefully and send in the coupon today.

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Aurora, Illinois, U.S.A.
Cable address "Bargreene"

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- ☐ **Have Barber-Greene representative call**
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- ☐ B-G Travel Plants
- ☐ B-G Bucket Loaders of ______ capacity
- ☐ B-G Permanent Conveyors
- ☐ B-G Portable Conveyors
- ☐ B-G Coal Yard Equipment
- ☐ B-G Ditchers
- ☐ B-G Snow Loaders
- ☐ B-G Belt Car Unloaders

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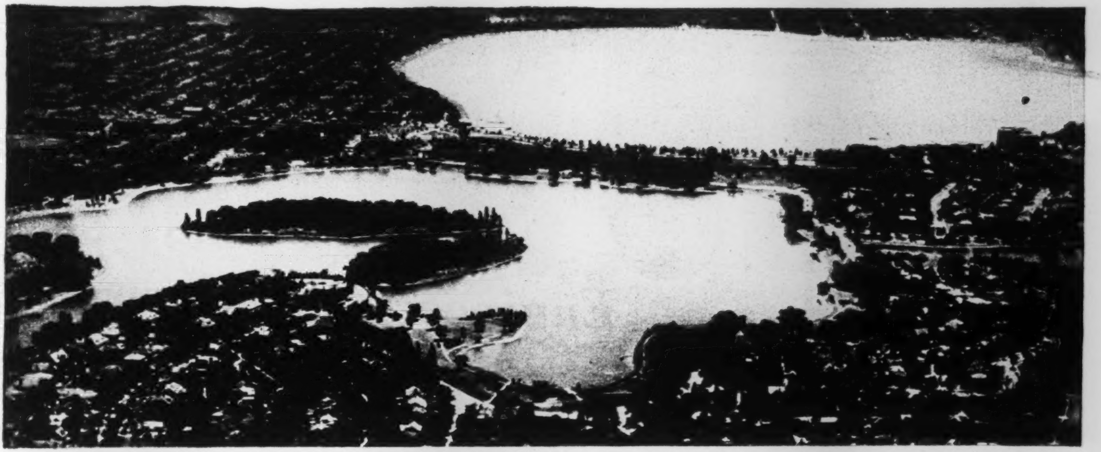
Your B-G Distributor can give you other cost-saving bulletins listed below:

Bulletin 4901	**Portable Conveyors**
Bulletin 4902	**Bucket Loaders**
Bulletin 4903	**Bituminous No. 1**
Bulletin 4904	**Ditchers**
Bulletin 4905	**Permanent Conveyors**
Bulletin 4907	**Bituminous No. 2**

BARBER-GREENE COMPANY
Aurora, Illinois, U.S.A.

Building a Greater America



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Reasons? You'll find one in every foot of Clay Pipe! Clay Pipe is the *only* pipe which is completely dependable — the *only* pipe which can possibly withstand the deteriorating action of acids, alkalies and chemicals. Rust-proof and corrosion-proof, *Clay Pipe never wears out!*

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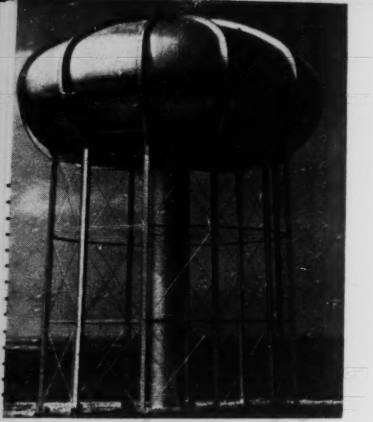

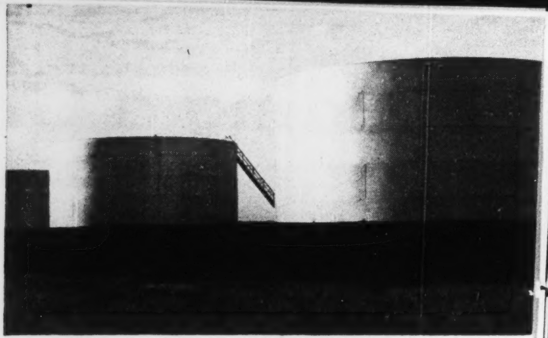

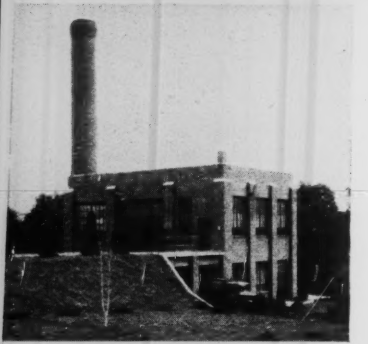

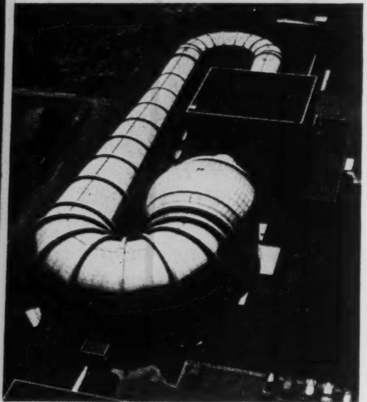

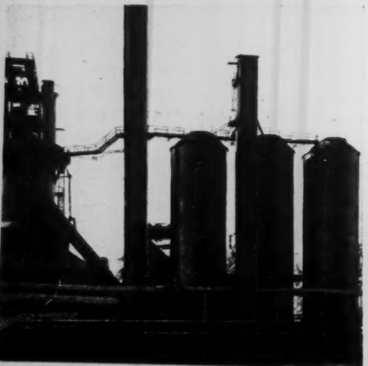

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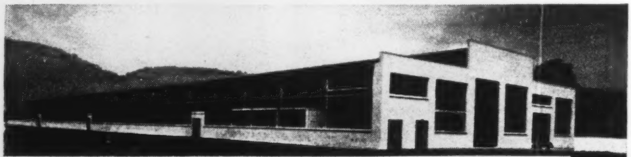

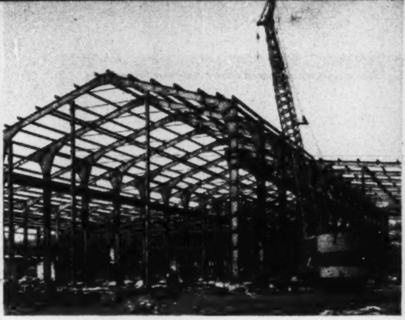

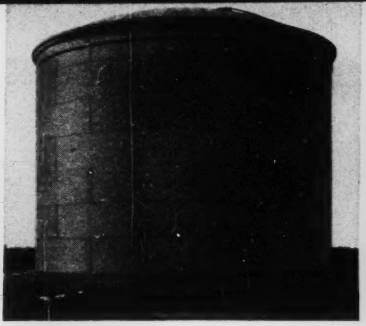

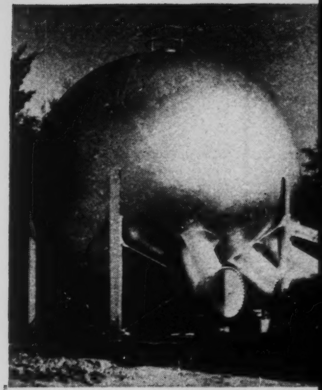

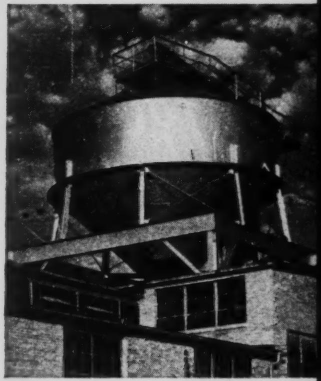

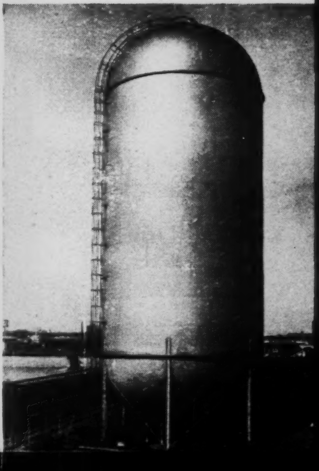

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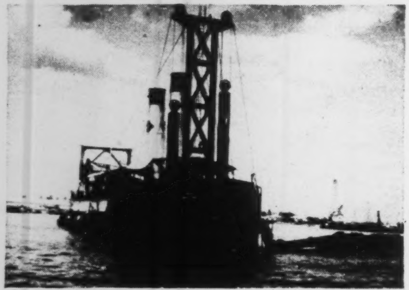

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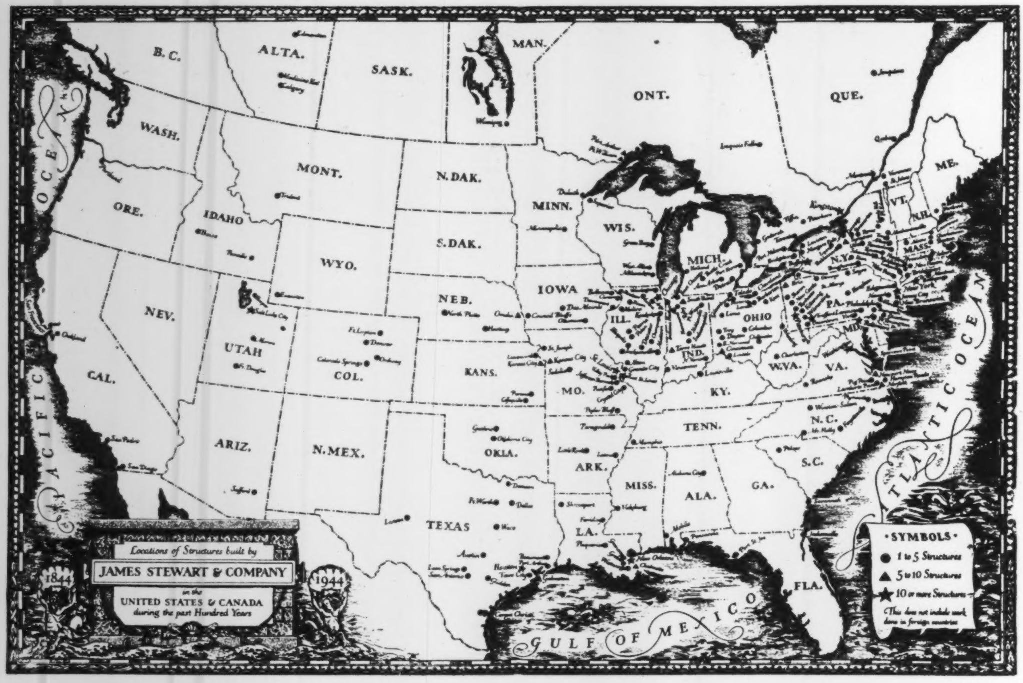
Monotube Foundation Piles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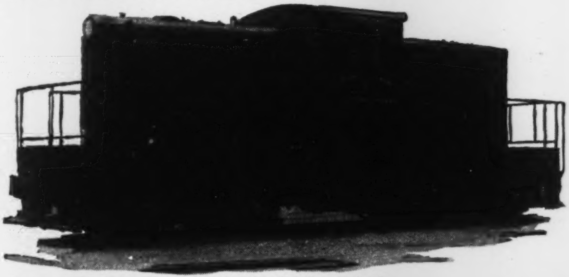
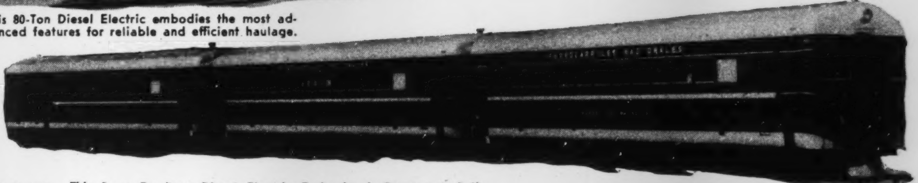


1948 This 80-Ton Diesel Electric embodies the most advanced features for reliable and efficient haulage.



1949 This 3-car De Luxe Diesel Electric Train (each Davenport Rail car is powered) was built for the Government of Colombia, S. A.

WHEN a construction project calls for rail haulage, the correct locomotive selection is important. Thousands of trips must be made and the cost per ton-mile may determine whether or not the job is profitable.

Since 1899, we have analyzed thousands of operating conditions and have built suitable haulage units for them. Davenports all over the world attest to the over-plus of stamina and the superb performance capabilities we build into our product.

Keeping pace with the advancing engineering and manufacturing techniques, Davenports, of the year in which they are built, represent the best rail power available.

Send us a description of your operating conditions and we will submit reliable recommendations without obligation on your part.

1935 Davenport Diesel Electric Locomotives, 16 of them, performed effectively on mammouth Coulee Dam.

1942 The Tennessee Valley Authority put Davenports into service which called for stamina and dependability.

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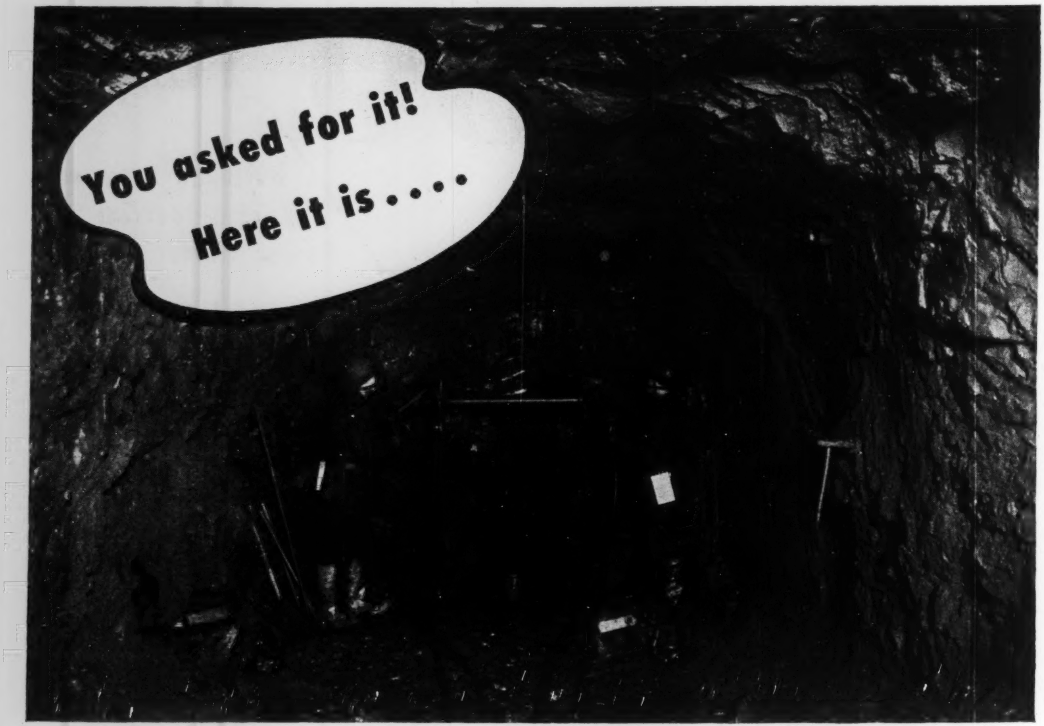

New *Homo-Flex* Heavy-Duty HOSE TEAM for WET DRILLING

Men who mine and quarry and excavate with wet drills have long demanded air and water hose that will withstand the scuffing and crushing of falling rock and rough working conditions. Manhattan engineers applied the Homo-Flex principle of hose construction to its hardest test . . and today you have your answer . . .

THE ROUGH, TOUGH TEAM OF *Condor* HOMO-FLEX HEAVY-DUTY AIR HOSE and HEAVY-DUTY WATER HOSE

Both of these rugged hose constructions feature extra thick cover protection that is literally "rubber armorplate". Every abusive blow rebounds from these new Homo-Flex constructions where lesser hose would be seriously gouged and injured.

Sharp bends over and around machines and rock are taken in stride by this tough team. Their sinewy hose walls stand up without kinking or collapsing. Thus, you can always be sure of a full feed of air and water to your wet drills.

Only Manhattan's exclusive principle of Homo-Flex construction makes possible this superior air and water hose team with their heavy-duty stamina to take this punishing service and still be flexible and easy to handle. In Homo-Flex, Manhattan engineers have developed a method of fusing tube, strength member and cover into one inseparable unit – for extra long life, extra margin of strength and safety, extra flexibility – extra value all around.

Don't overlook this opportunity to equip your wet drills with Condor Homo-Flex Heavy-Duty Air Hose and Heavy-Duty Water Hose—It's the team you asked for—developed specifically for your problems.

The Air Hose type with its oil-proof tube is also unmatched in performance in other heavy-duty mining, quarry, and construction operations.

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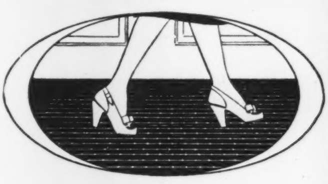

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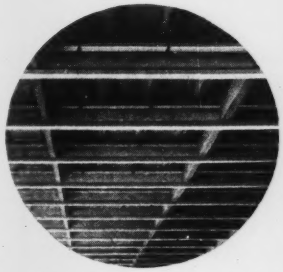

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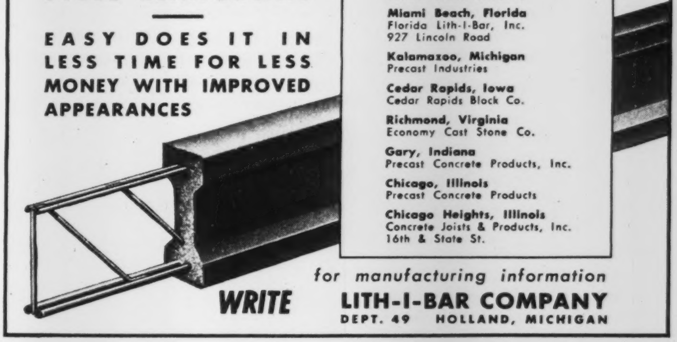

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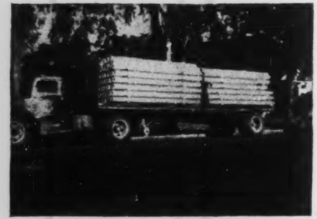
Here's how TRANSITE PRESSURE PIPE meets these 7 basic water-line problems . . .

IF YOU are faced with some—or all—of these 7 common water-line problems, here is information about Johns-Manville Transite* Pressure Pipe that may be of help to you...facts that tell how this modern asbestos-cement pipe is helping to solve these problems in many communities.



1. Handling costs:

Because it is light in weight and easy to handle, Transite Pressure Pipe keeps handling costs down. Loading, unloading, and all other subsequent handling operations are simplified. More footage can be hauled per truckload—reducing trucking costs—and distribution along the trench is easier and more quickly accomplished. Moreover, mechanical handling equipment is not necessary except where larger sizes are being used; the pipe sections are easily lowered into the trench with rope slings.

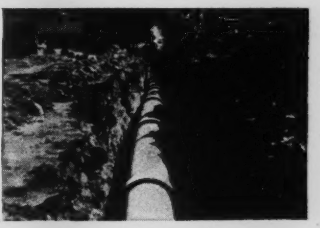
2. Installation costs:

Transite Pressure Pipe offers important economies that help combat increasing costs of water-line installation. It is quickly and easily assembled in the trench. A coupling puller is the only tool necessary. Often, the pipe can be assembled so rapidly that the same foreman supervises both excavation and installation. The speed with which Transite is assembled means that the job is completed with a minimum of time and labor, thereby contributing important reductions in the overall cost of the system.

*Transite is a Johns-Manville registered trade mark

3. Soil corrosion:

Two factors give Transite Pressure Pipe exceptional resistance to corrosion: (1) the corrosion-resistant materials of which it is made; (2) the especially developed Johns-Manville process of manufacture which imparts a high degree of chemical stability to the finished pipe. This high resistance to corrosion has been substantiated by numerous installations. Many of these are serving as replacements in soils so destructive that the useful life of the pipe materials previously used had been seriously curtailed.

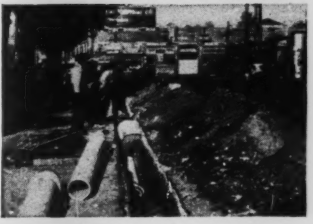


4. Internal corrosion:

Transite Pipe, because of its asbestos-cement composition, is not affected by tuberculation. Therefore, it is not necessary to resort to pipe of larger diameter to offset the internal effects of this costly form of pipe corrosion. And because progressive reduction of delivery due to tuberculation capacity is never a problem in a Transite pipe line, pressures and flows remain high—pumps operate at higher efficiencies. These factors that are often reflected in better service and lower water rates in communities served by Transite lines.

5. Joint leakage:

Transite's Simplex Coupling was designed to minimize underground leakage . . . and to provide maximum protection against failures resulting from trouble at joints. It consists of only three parts: a Transite sleeve, machined to fit over the pipe ends, and two rubber rings which, when assembled, are tightly compressed between pipe and sleeve. The joint thus formed is tight and flexible. It remains tight in service. Furthermore, each joint may be checked for proper assembly immediately upon completion.



6. Vibration and stresses:

Transite's flexible joints effectively absorb the vibration of heavy traffic—an especially important factor where pipe is laid under busy highways, or near railroad and street car tracks. Because each joint is capable of deflection up to five degrees, the entire line has a flexibility not ordinarily found in other types of waterline construction. This helps compensate for soil movements and other stresses to which the pipe may be subjected . . . provides an effective safeguard against costly pipe failures.

7. Maintenance:

In thousands of communities, Transite Pipe—with its advantages of joints that remain tight and flexible, its corrosion resistance, and immunity to tuberculation—provides low-cost water transportation that requires little, if any, maintenance. Transite lines do not have to be cleaned, lined, or replaced because tuberculation has reduced their original capacity. Reports from communities all over the country prove that Transite's asbestos-cement structure provides economies that continue through the years.

If you would like additional information about Transite Pressure Pipe, write to Johns-Manville, Box 290, New York 16, N.Y. Ask for Brochure TR-11A.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville Transite Pressure Pipe

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WRITE TODAY for these 2:
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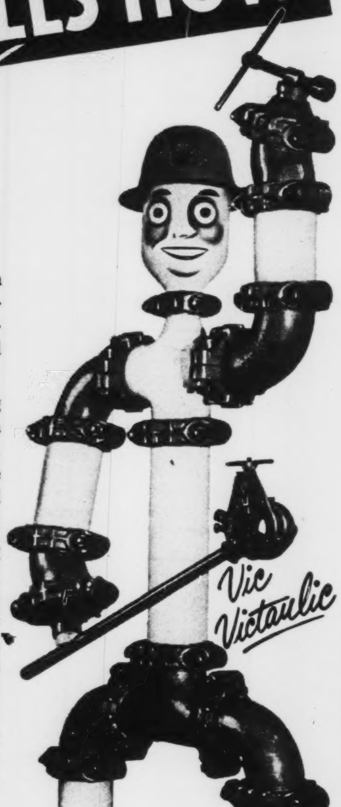
- *"Vic-Groover" Catalog No. VG-47.



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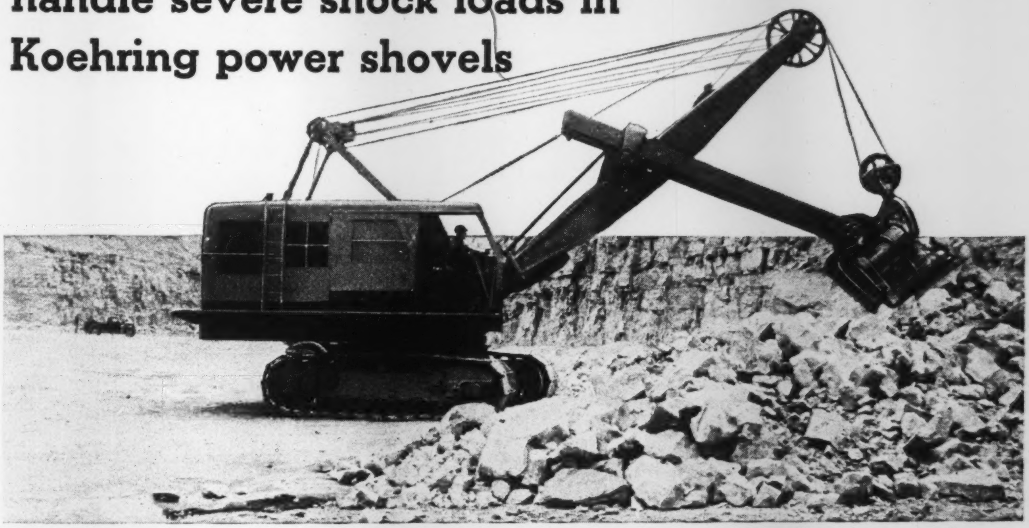
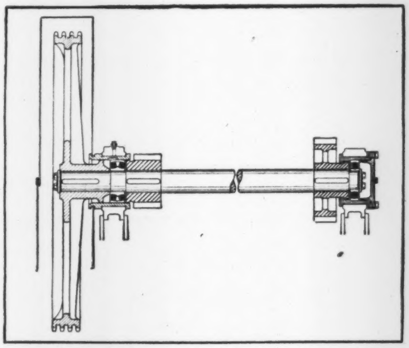
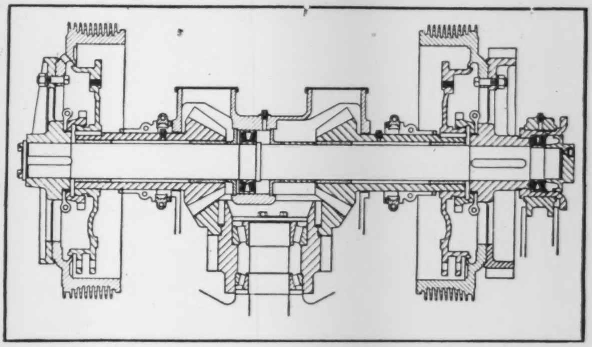
Torrington Spherical Roller Bearings handle severe shock loads in Koehring power shovels



Power Shovels made by Koehring Company, Milwaukee, are built to withstand the severe shocks and strains encountered in this rugged service. Among many advanced engineering features is the use of Torrington Spherical Roller Bearings on the swing and traction shaft and the countershaft. They compensate for deflection and prevent binding under shock loads.

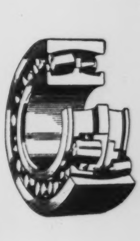


Cross-Section of the countershaft shows how a Spherical Roller Bearing is used to maintain free-rolling alignment despite the overhung sheave and sudden stresses of operation. These heavy-duty bearings carry high loads with an ample margin of safety.



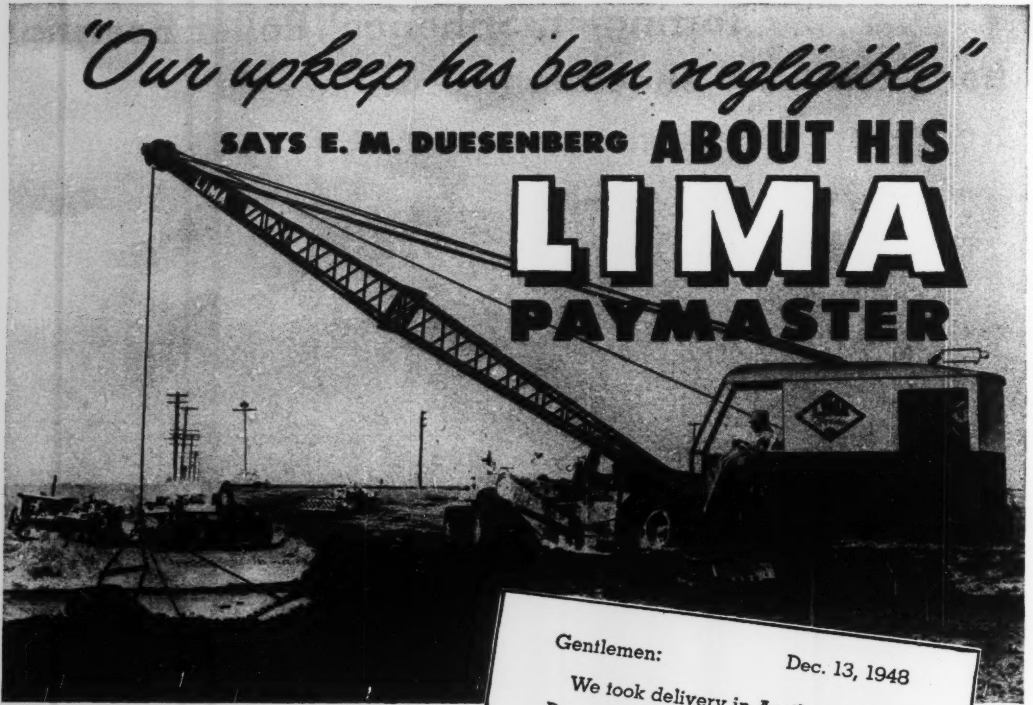
Two Spherical Roller Bearings are used on the horizontal swing and traction shaft. Here, too, the self-aligning feature is important, insuring accurate alignment of bearings spaced some distance apart. Because they carry thrust loads in either direction, these bearings also locate the shaft axially, preventing play and helping to minimize wear on bevel gears.

To power shovels, vibrating screens, hammer mills, rock crushers and other heavy-duty equipment, Torrington Spherical Roller Bearings bring operating advantages. Our engineers will gladly help you in adapting them to the machinery you make or use. Write us today. THE TORRINGTON COMPANY, South Bend 21, Ind., or Torrington, Conn. District offices and distributors in principal cities of United States and Canada.



TORRINGTON SPHERICAL ROLLER BEARINGS

Spherical Roller • Tapered Roller • Straight Roller   Needle • Ball • Needle Rollers


"Our upkeep has been negligible"
SAYS E. M. DUESENBERG ABOUT HIS
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PAYMASTER
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Gentlemen: Dec. 13, 1948

We took delivery in April on a Lima Paymaster "34" Dragline. We have used the machine steady since that time on our various highway projects and think very highly of its performance. Our upkeep has been negligible and the men on the projects think it is one of the best machines on the job. We are glad to recommend this model to anyone and wish to compliment your company on building a fine machine.

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(Signed) E. M. Duesenberg

The LIMA (type 34) Paymaster is a favorite with owners and operators because of its proven ability to *STAY ON THE JOB.* This is the result of expert engineering, superior workmanship and higher quality materials which go into every LIMA unit, and the gruelling performance tests subjected to every machine before shipment.

The LIMA line includes Shovels ¾ to 6 yards, Cranes 13 to 110 tons and Draglines variable.

It will pay you to consult your nearest Lima Sales Office or representative before you buy your next shovel, crane or dragline. Offices in principal U.S. cities.

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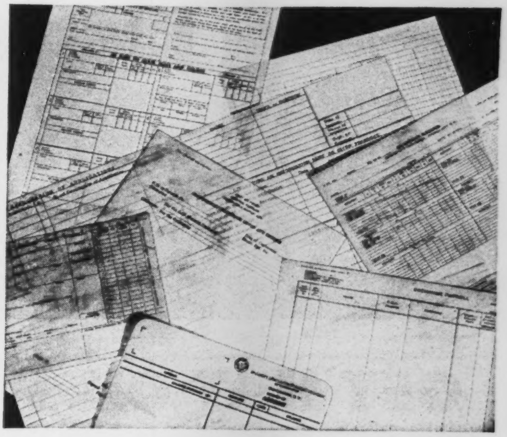

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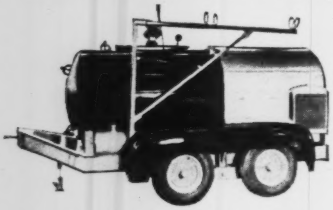
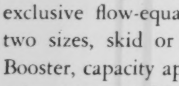


The Cleaver-Brooks Pumping Booster heats only the amount of material required — not necessary to heat entire car. No steam or water required for operation with this oil fired, high efficiency unit. Cleaver-Brooks pumping boosters heat to high temperatures faster through the exclusive flow-equalizer feature. Available in two sizes, skid or trailer mounted — No. 1 Booster, capacity approx. 300 gph, temperature raise 25 to 35°F., No. 2 Booster, capacity approx. 35° gph, temperature raise 45 to 55°F.



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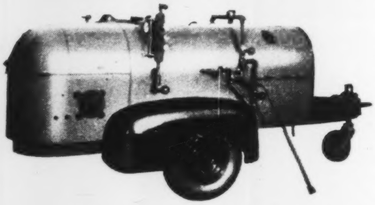
TANK CAR HEATER



A Cleaver-Brooks Tank Car Heater is the starting point for fast work on any construction project. A faster job means man hours saved — contracts completed on time and without penalties. Designed for fast steaming, this unit gives you 125 lbs. steam pressure in 20 minutes with high heat transfer and low fuel consumption. Available in two sizes, skid or trailer mounted — Two car heater (28 bhp), Three car heater (42 bhp).

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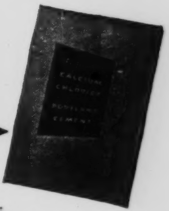
WHAT WILL CALCIUM CHLORIDE DO FOR GOOD CONCRETE?

Here Are the Facts!



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The effect of Calcium Chloride on slump? . . . flow? . . . Workability? . . . density? . . . water-cement ratio?

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How much Calcium Chloride will reduce the curing period?

The effect on volume change? . . . surface wear?

These are just a few of the questions answered in this new book. "The Effects of Calcium Chloride on Portland Cement" is just off the press. Write for your copy today—no obligation.

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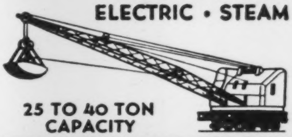

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DESCRIPTION OF JOB: Retaining Walls, 17′0 high, length 163′10″, width 76′ 10″, corners large bevel inside, right angle outside, provision for manhole steps.

Locality
N. Y. Metropolitan District

Date of work
July, 1949

Weather
Hot

Job# 1851

Form uses
11

Form uses possible without repair
400

Hand or crane handled
Crane

Crane cost
$11.43 per hr.

Openings
None

Pour
4′ liquid head

Carp. rate
$3.00

Labor costs per 100 sq. ft.

Work	Hrs.	Trade	Rate per hour	Total	Uses	Total cost per 100 sq. ft.	Cost sq. ft.
Make panels	3¾	Carp.	$3.00	$11.25	11	$1.00	1¢
(Made forms into panels 12′ x 17′ and 18′ x 17′ maximum weight 12/tons 204 sq. ft.)							
Erection	1½	Carp.	3.00	4.50	1	4.50	4½¢
Includes placing of all snap ties, lining up forms, etc., ready for pouring							
Crane $11.53 per hour, charged to this 100 sq. ft. $1.00							1¢
Strip, move, clean	1	Carp.	3.00	3.00	1		3¢
Crane rental, as above				1.00 10.50			1¢ 10½¢

Remarks: All carpenters were used, no laborers, account of requiring larger number of carpenters for balance of work.

Caution: Form costs vary according to many factors, such as quality of work and supervision, receipt of materials without delay, weather, changes in plans, scheduling, etc. Atlas Speed Forms will reduce your costs very materially, but all the factors applying to a particular job should be borne in mind.

Let us give you a study of costs on the next job you figure, based on the most recent data we have from your part of the country. A substantial reduction in your concrete costs may win you the job. Send us your plans—we will return them promptly, with a cost study. No obligation.

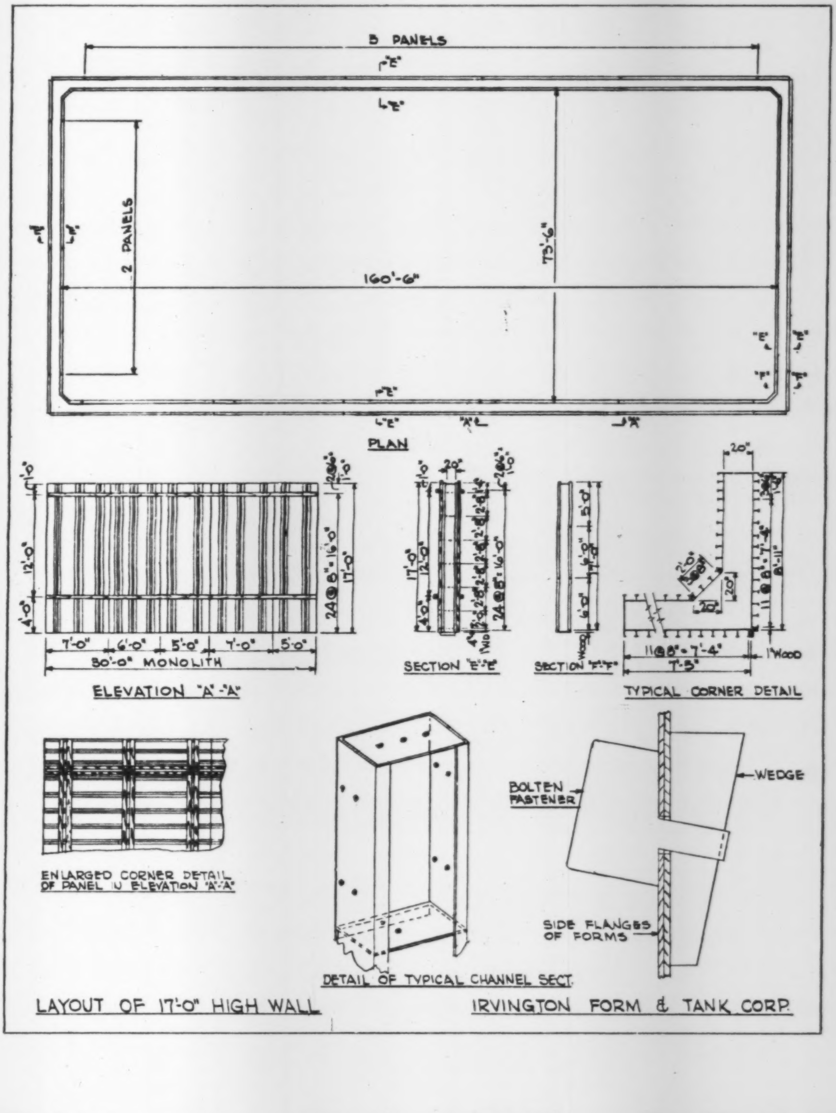
Atlas service includes advice, lay out drawings, services of a competent field supervisor, etc.

There is an Atlas Steel Form for every purpose, for rent or sale.

IRVINGTON

using . . .

ATLAS SPEED FORMS



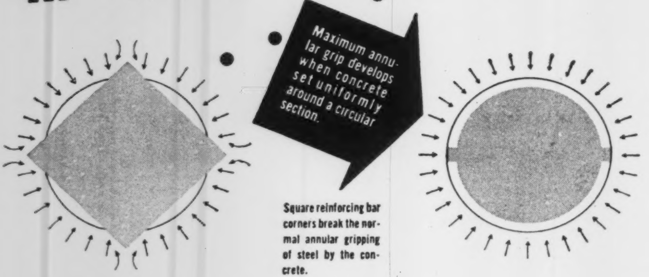
8 PANELS
"E"
"E"
2 PANELS
"F"
"F"
73'-6"
160'-6"
"E"
"E"
"F"
"F"
"E"
"E"
"A"
"A"
PLAN
12'-0"
4'-0"
1'-0"
2'-6"
1'-0"
24@8"=16'-0"
17'-0"
7'-0"
6'-0"
5'-0"
7'-0"
5'-0"
30'-0" MONOLITH
ELEVATION "A"-"A"
20"
17'-0"
12'-0"
4'-0"
24@8"=16'-0"
SECTION "E"-"E"
5'-0"
6'-0"
6'-0"
WOOD
SECTION "F"-"F"
20"
20"
20"
11@8"=7'-4"
8'-11"
7'-5"
1" WOOD
TYPICAL CORNER DETAIL
ENLARGED CORNER DETAIL OF PANEL IN ELEVATION "A"-"A"
DETAIL OF TYPICAL CHANNEL SECT.
BOLTEN FASTENER
WEDGE
SIDE FLANGES OF FORMS
LAYOUT OF 17'-0" HIGH WALL
IRVINGTON FORM & TANK CORP.

FORM & TANK CORP.

IRVINGTON 29 **NEW YORK**

The Seventh of a Series in the interest of more efficient use of steel . . . a vital American resource

For the BEST ANCHORAGE don't put "square pegs". in "round holes". . .


Maximum annular grip develops when concrete set uniformly around a circular section.

Square reinforcing bar corners break the normal annular gripping of steel by the concrete.

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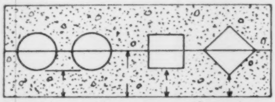
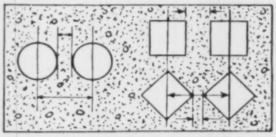


Round bar sections assure uniform clearance and coverage by the concrete.



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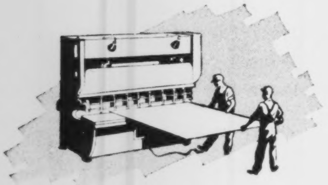

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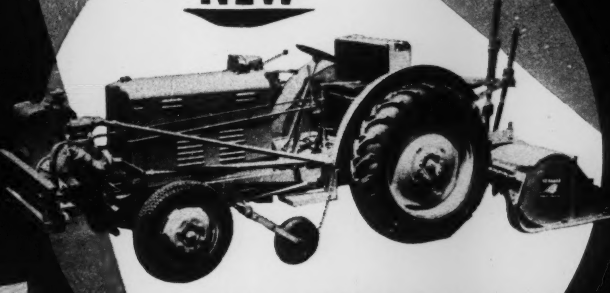

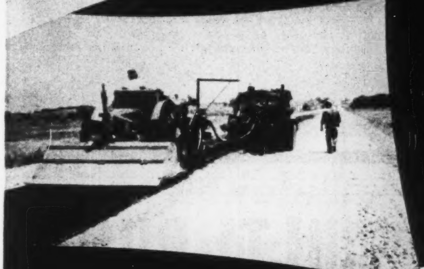

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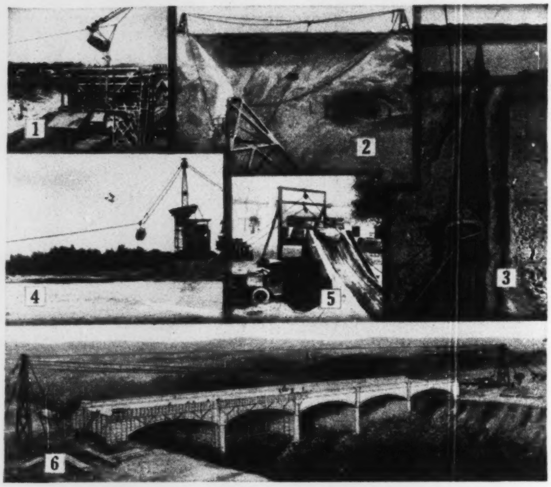

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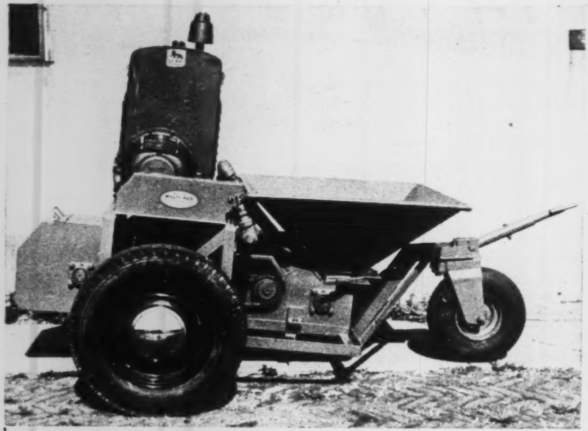

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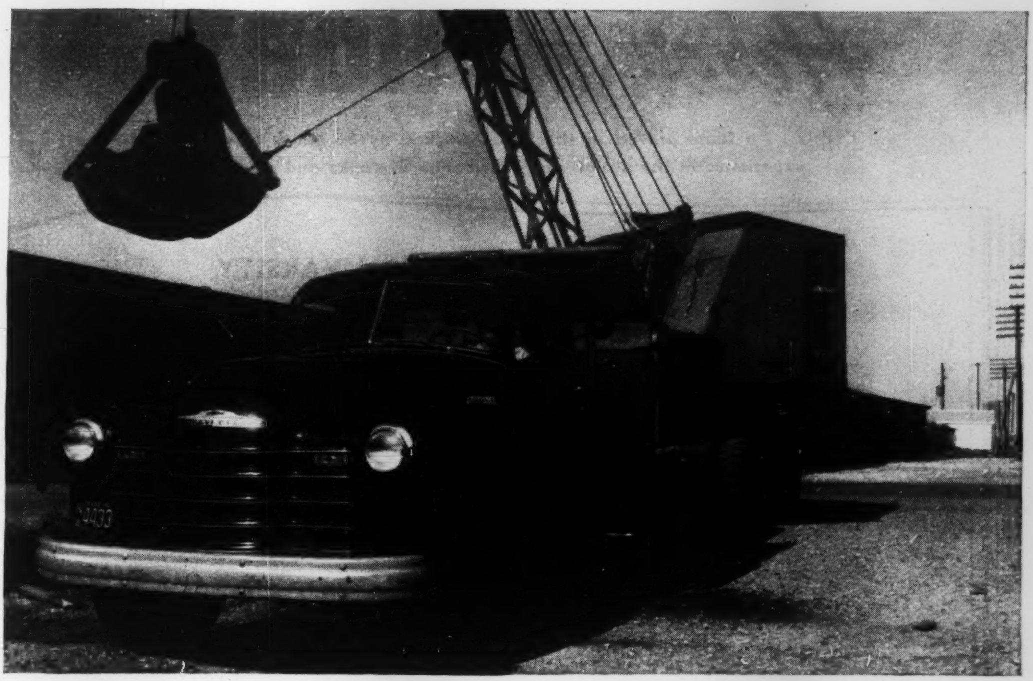

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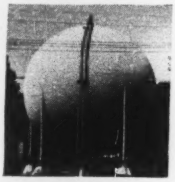

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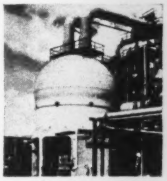

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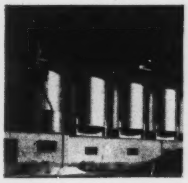

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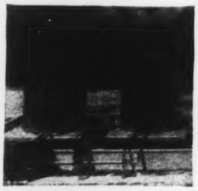

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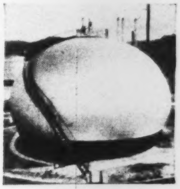

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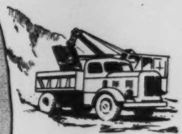

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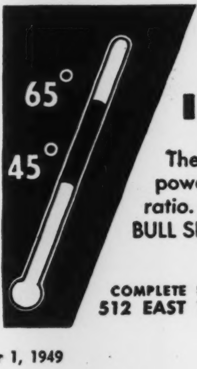

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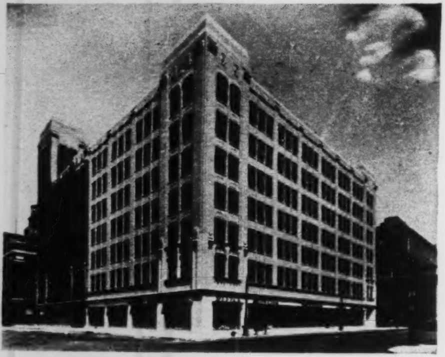

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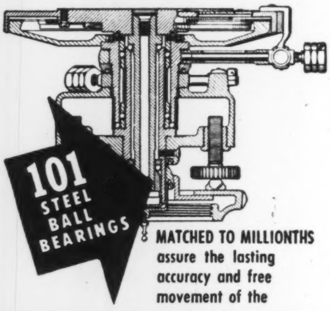

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Permanently lubricated and factory sealed against dust, the Brunson Ball-Bearing Base allows a total eccentricity of not more than + or — ¼ second of angular error. To obtain this accuracy, it is necessary for us to engineer and produce in our own plant these Bearings and spindles—each stabilized to the accuracy of precision gauge blocks. Because these ball bearings are pre-loaded and operate under tension, they remove all grease from the point of contact. This assures greater accuracy than any other type of bearing which must allow for grease or oil film. *Write for details.* **Patented.*

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"Because I figured competition's bound to get tougher. I wanted a shovel that could cover lots of ground and make better money on all kinds of jobs. Take it from *me*, if you want to get the most for your money, get a MICHIGAN!

"IT'S FAST ON THE ROAD—
Gets to the job as fast as a truck, and under its own power.

"IT MOVES DIRT FAST—
Anyway you look at it, it's *yardage* that counts. MICHIGAN'S 5.4 RPM swing and fast air clutches give you the extra yards a day you're after.

"IT'S *REALLY* BUILT—
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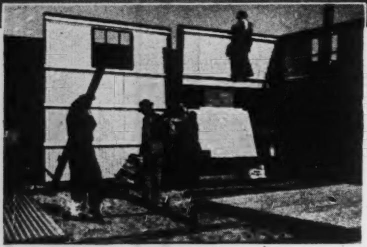
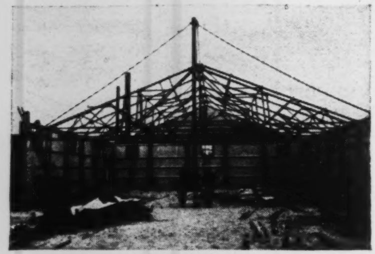


Up she goes—easy does it!



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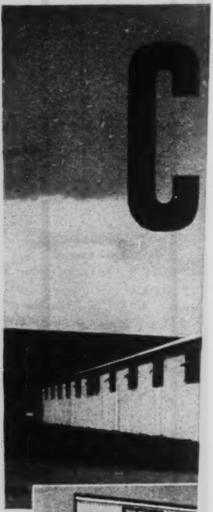

Up she go

After only 4 hours' work!

up to 80 feet. Standard units may be combined to fit practically any building requirements. Unique design permits ready expansion or adaptation as needs require.

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- Commercial Buildings
- Storage Buildings
- Oil Refineries
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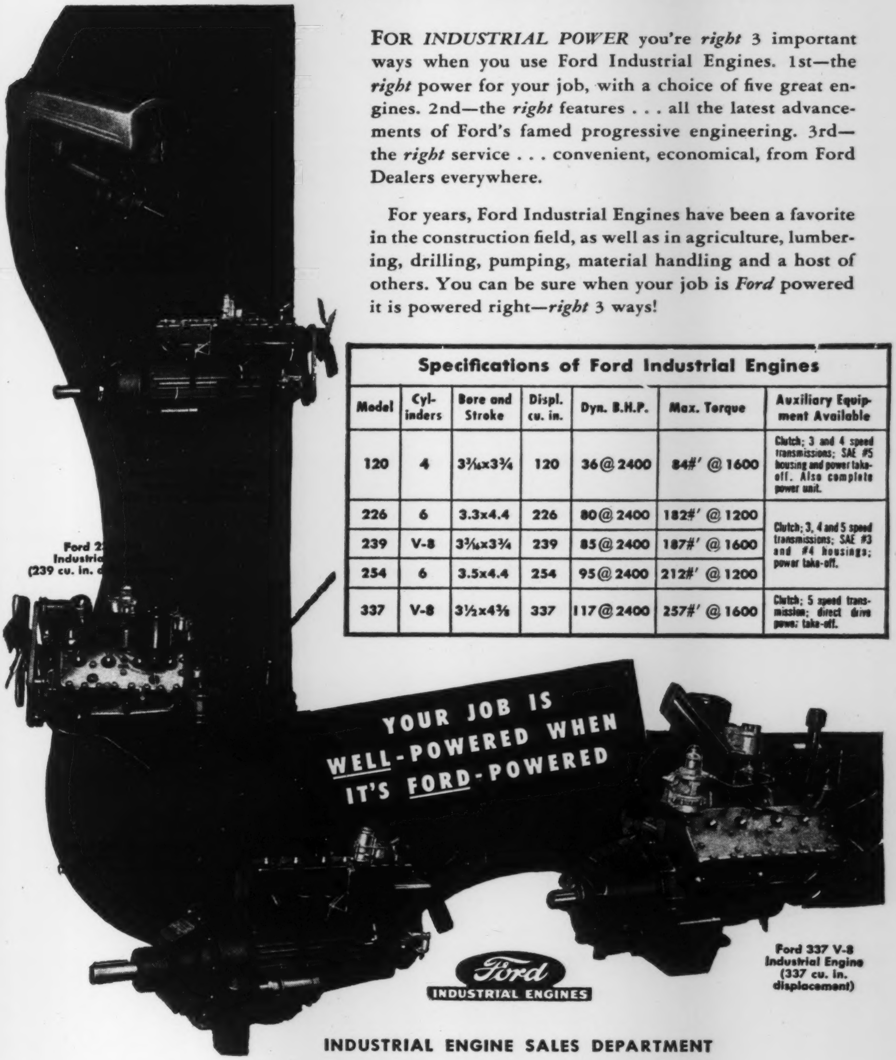
120	4	3³⁄₁₆x3¾	120	36@2400	84#' @1600	Clutch; 3 and 4 speed transmissions; SAE #5 housing and power take-off. Also complete power unit.
226	6	3.3x4.4	226	80@2400	182#' @1200	Clutch; 3, 4 and 5 speed transmissions; SAE #3 and #4 housings; power take-off.
239	V-8	3³⁄₁₆x3¾	239	85@2400	187#' @1600	
254	6	3.5x4.4	254	95@2400	212#' @1200	
337	V-8	3½x4⅜	337	117@2400	257#' @1600	Clutch; 5 speed transmission; direct drive powe; take-off.



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(239 cu. in. d

Ford 337 V-8
Industrial Engine
(337 cu. in.
displacement)

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FORD MOTOR COMPANY
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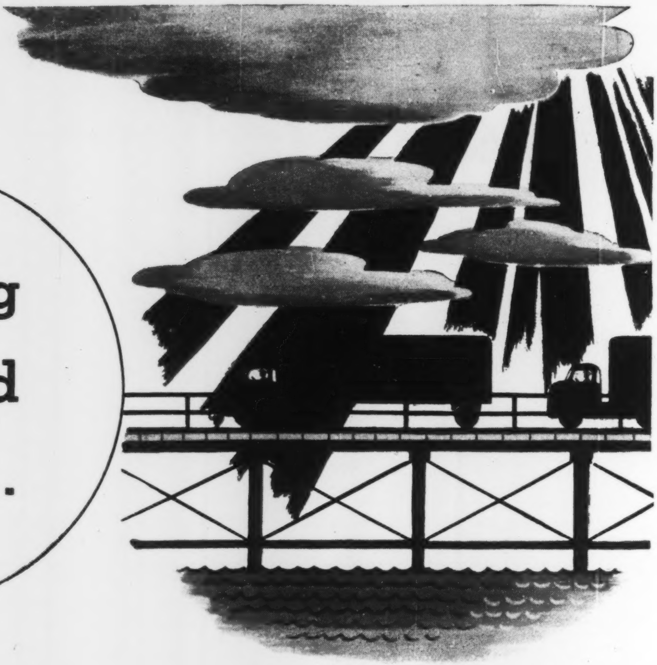

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JOY K-81, a rugged tool capable of sustained operation on the heaviest demolition work.

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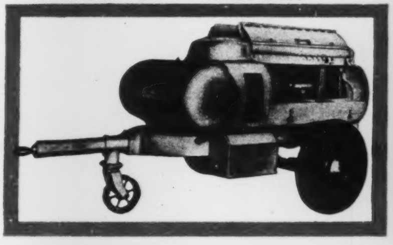

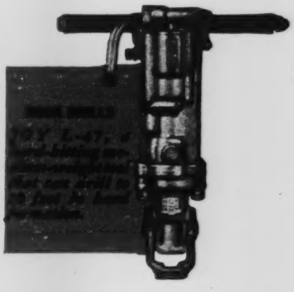

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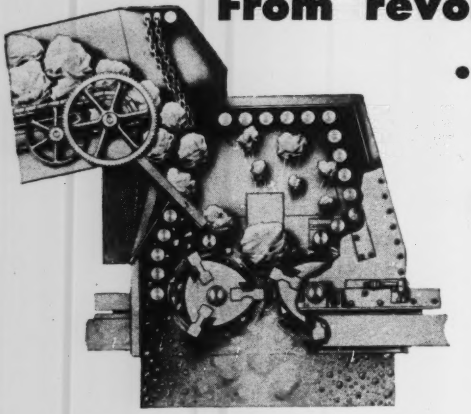

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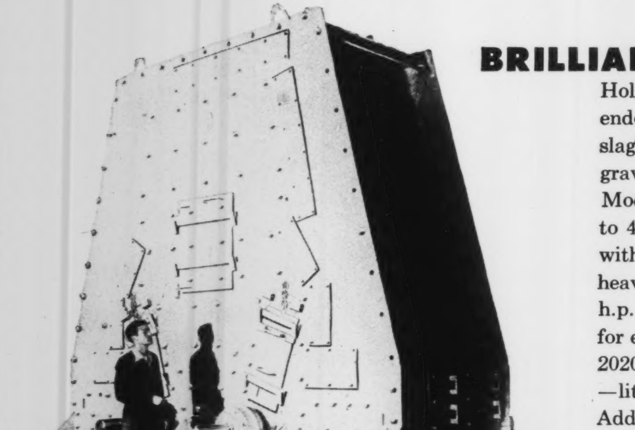

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NEW HOLLAND MANUFACTURING COMPANY, MOUNTVILLE, PA.

Affiliate of The Sperry Corp.

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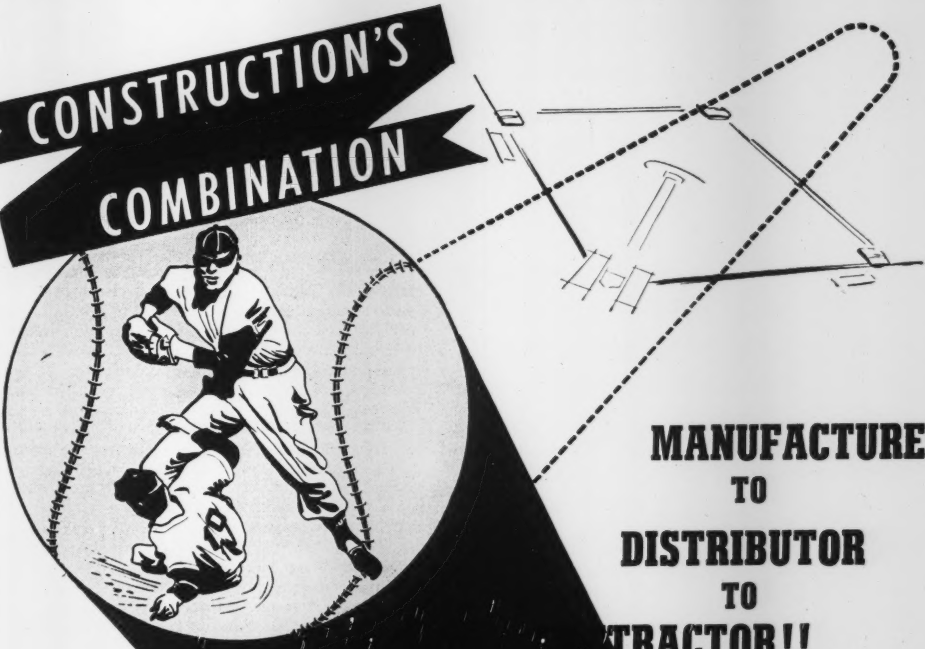

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One of baseball's gr
kling double play, occu
with enemy runners on
team in trouble. In this criti
ness, split-second timing, an
dling are essential to pull the g
fire.

By the same token, the construction
has a first-class double play combinatio
own, rising to meet emergencies of one s
another scores of times daily. Wheneve
crisis arises on the job, requiring swift, com
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Backed by years of experience and a thorough-going knowledge of customers' needs, this

wise geared to meet every
of the equipment user on
um of delay and a maxi-
efficiency.

ooperative relationship
lly every play—is the
tributor. A thorough
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th any on-the-job
an ever present
equipment user

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cturer-to-dis-
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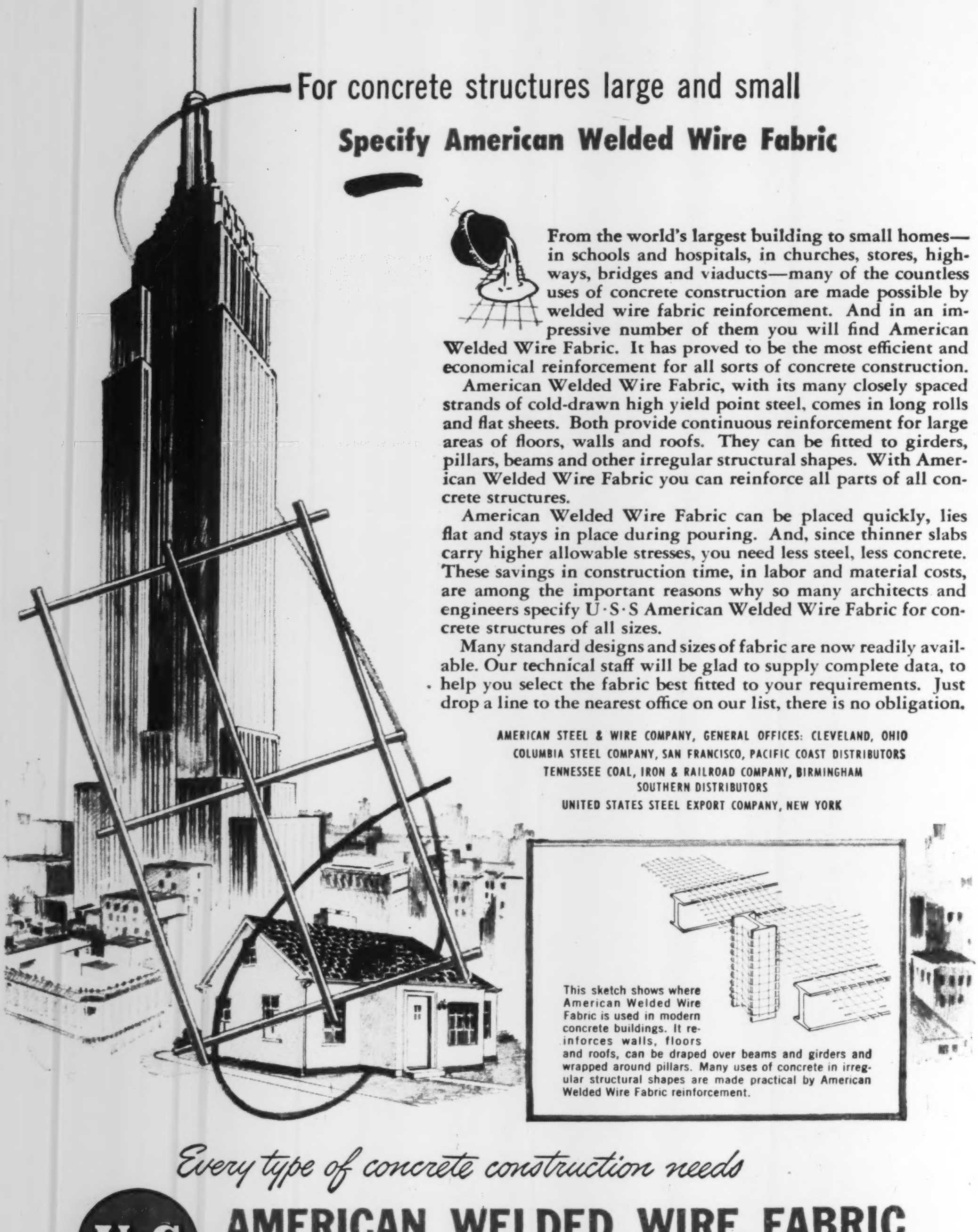

For concrete structures large and small

Specify American Welded Wire Fabric

From the world's largest building to small homes—in schools and hospitals, in churches, stores, highways, bridges and viaducts—many of the countless uses of concrete construction are made possible by welded wire fabric reinforcement. And in an impressive number of them you will find American Welded Wire Fabric. It has proved to be the most efficient and economical reinforcement for all sorts of concrete construction.

American Welded Wire Fabric, with its many closely spaced strands of cold-drawn high yield point steel, comes in long rolls and flat sheets. Both provide continuous reinforcement for large areas of floors, walls and roofs. They can be fitted to girders, pillars, beams and other irregular structural shapes. With American Welded Wire Fabric you can reinforce all parts of all concrete structures.

American Welded Wire Fabric can be placed quickly, lies flat and stays in place during pouring. And, since thinner slabs carry higher allowable stresses, you need less steel, less concrete. These savings in construction time, in labor and material costs, are among the important reasons why so many architects and engineers specify U·S·S American Welded Wire Fabric for concrete structures of all sizes.

Many standard designs and sizes of fabric are now readily available. Our technical staff will be glad to supply complete data, to help you select the fabric best fitted to your requirements. Just drop a line to the nearest office on our list, there is no obligation.

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This sketch shows where American Welded Wire Fabric is used in modern concrete buildings. It reinforces walls, floors and roofs, can be draped over beams and girders and wrapped around pillars. Many uses of concrete in irregular structural shapes are made practical by American Welded Wire Fabric reinforcement.

Every type of concrete construction needs

AMERICAN WELDED WIRE FABRIC

reinforcement

USS

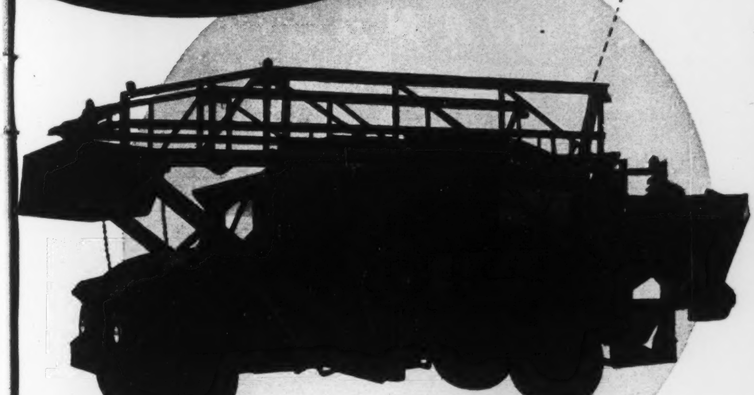
UNITED STATES STEEL

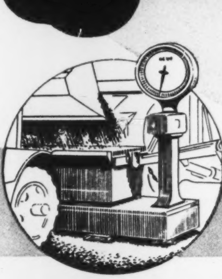
Extra Profits...

ONE-YARD

MIXERMOBILE

Model M-61





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Attached 25-ft. tower with standard 10-ft. extensions.

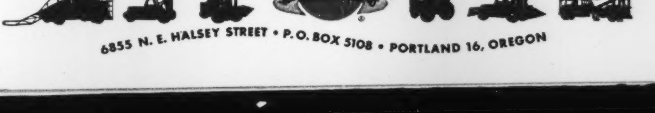
A COMPLETE MOBILE CONCRETE MIXING UNIT AND ELEVATOR

Saves time and labor! More jobs covered! Less Maintenance! The One-Yard Mixermobile is the most economical method of handling concrete on the job. Costs of hauling and erecting expensive equipment are eliminated. Labor costs are minimized. One man at centralized controls handles the entire operation..."sets-up" equipment ready for pouring ...then controls every operation from dump truck to deck. The One-Yard Mixermobile can turn out 200 cu. yds. of concrete in 8 hours. Also provides valuable storage space when handling ready-mix concrete. It travels at highway speeds comparable to trucks with similar loads.

FOR GREATER CONCRETE CONSTRUCTION SAVINGS CONTACT YOUR NEAREST DEALER

NOTE: The Mixermobile Manufacturers reserve the right to make improvements in design and specifications without notice.

MIXERMOBILE MANUFACTURERS



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MIXERMOBILE CO., INC.	Los Angeles, Calif.
RHODES & JAMIESON LTD.	Oakland, Calif.
CAPITOL TRACTOR & EQUIP. CO.	Sacramento, Calif.
CONSTRUCTORS EQUIPMENT CO.	Denver, Colo.
NEFF-THOMAS MACHINERY CO.	Miami, Fla.
SQUARE DEAL MACHINERY & SUPPLY CO.	Orlando, Fla.
TRACTOR & MACHINERY CO.	Atlanta, Ga.
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HALL-PERRY MACHINERY CO.	Butte, Mont.
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MACK TRUCK SALES	Reno, Nev.
E. H. KLIEBENSTEIN CO.	Ridgefield, N. J.
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SLADE TRACTOR CO.	Albany, N. Y.
RUPP EQUIPMENT CO.	Buffalo, N. Y.
DRYDEN SUPPLY CO.	Dryden, N. Y.
HODGE & HAMMOND, INC.	New York, N. Y.
RUPP EQUIPMENT CO.	Rochester, N. Y.
CREDLE EQUIPMENT, INC.	Utica, N. Y.
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WILLIAMS COMPANY, THE, W. W.	Columbus, Ohio
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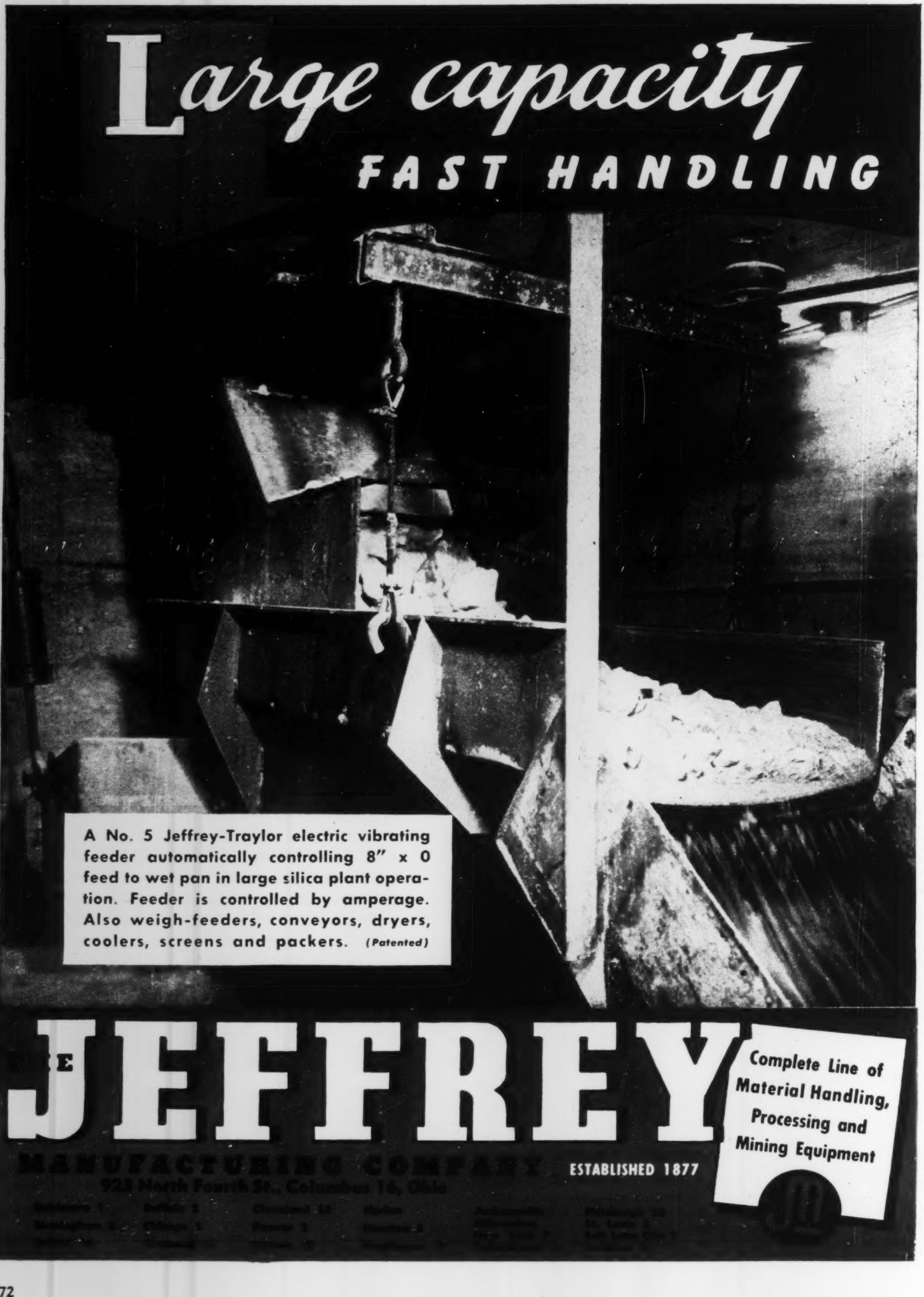

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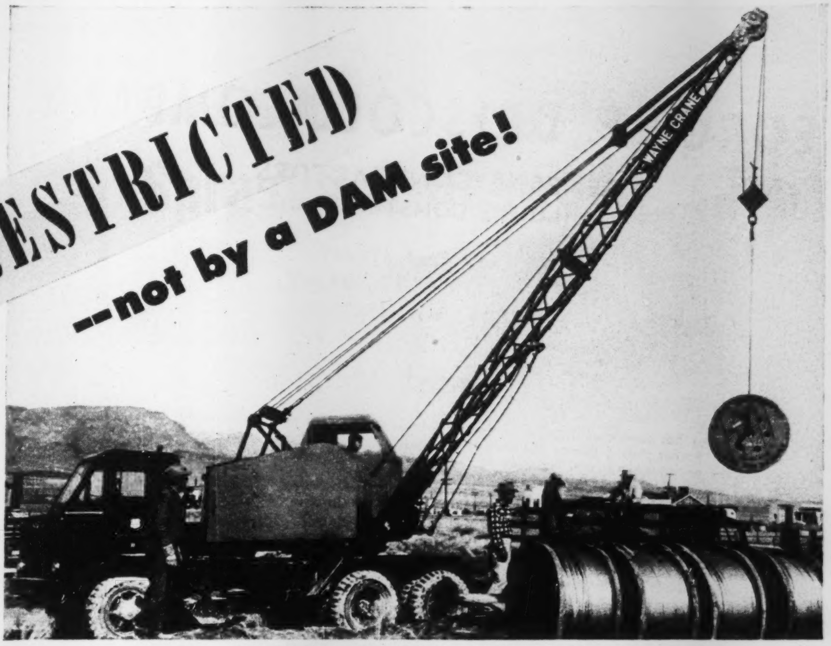

The Wayne Crane Model 44 "Corsair," ½-yard, 10-ton machine, above as a utility crane unloading power cable at the Parker Dam Site in Arizona.

"Corsair" is not restricted to one job . . . it MOVES FAST from job to job — truck speeds on the highway. From the dam site at Parker to Needles, Calif., Kingman, Phoenix and Tucson, Arizona, to Boulder Dam, the Bureau of Reclamation's "Corsair" travels to its work . . . saves cost of permanent "local" equipment for infrequent loading and "handling" jobs.

For contractors, public utilities, railroads, municipal, county and state governments, "Corsair" offers the broad utility that "pays off" quickly in rental savings.

Today you need WAYNE CRANE advantages: fast 5½ r.p.m. swing, enclosed gears running in oil, oversize clutches and drums, anti-friction bearings, worm-driven boom hoist, full-vision cab and many other operational features which WAYNE CRANE provides. Converts easily to Shovel, Trench Hoe, Dragline, Clamshell, Pile Driver or Magnet Crane.

The Special Heavy-Duty "Corsair" Carrier is engineered for crane service. The extra large base plate of the upper-structure spreads the load evenly over the heavy box-type truck frame. Outriggers provide additional bearing support for maximum stability. Wayne Crane's performance, operating economies and low maintenance cut costs on any job.

WAYNE CRANE "Corsair" TRUCK-MOUNTED MODEL 44

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Wayne Crane Division, American Steel Dredge Co. Inc., Fort Wayne 1, Indiana, U. S. A.

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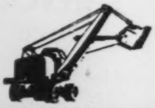
For yard work and home town jobs. Convertible to Shovel, Trench Hoe, Dragline, Clamshell, Crane, Magnet



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1/2 - yard, 5 - ton, rubber - mounted, self - propelled, one - man operated single engine machine.

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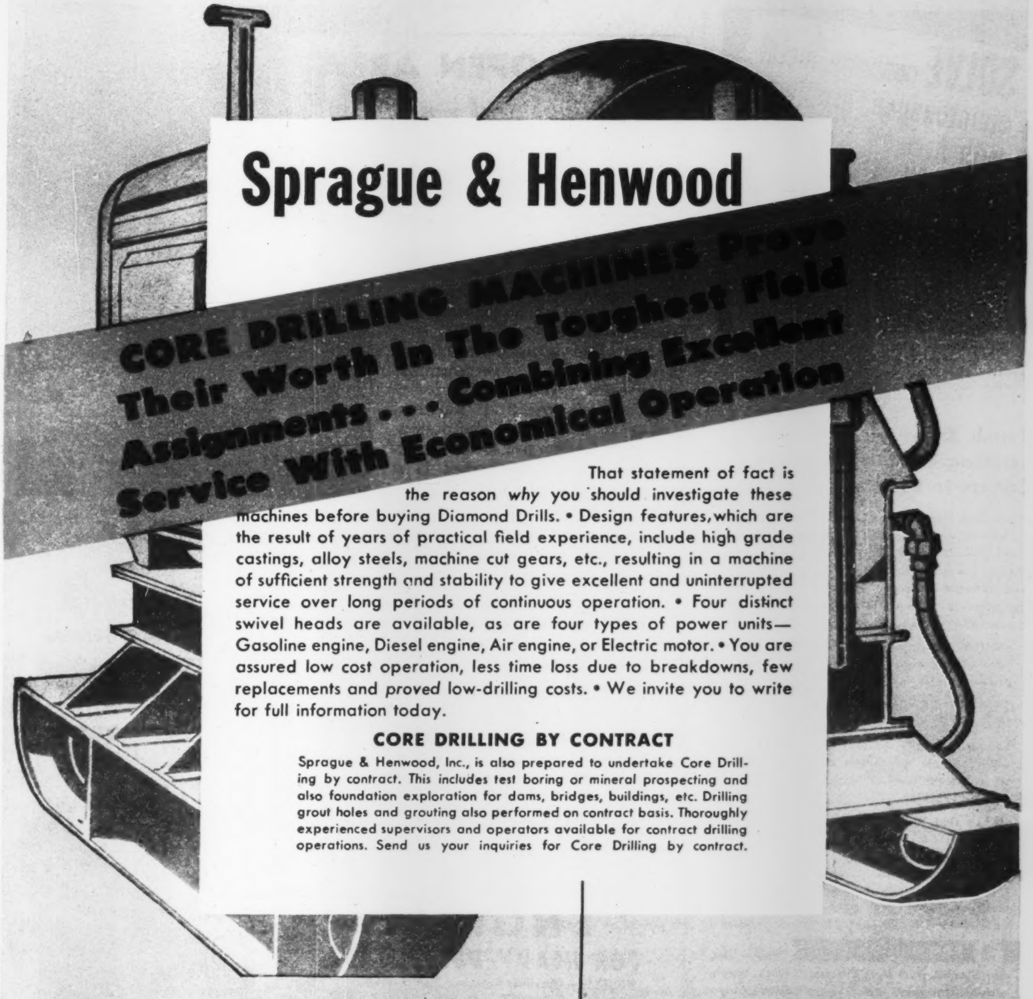

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That statement of fact is the reason *why* you should investigate these machines before buying Diamond Drills. • Design features, which are the result of years of practical field experience, include high grade castings, alloy steels, machine cut gears, etc., resulting in a machine of sufficient strength and stability to give excellent and uninterrupted service over long periods of continuous operation. • Four distinct swivel heads are available, as are four types of power units—Gasoline engine, Diesel engine, Air engine, or Electric motor. • You are assured low cost operation, less time loss due to breakdowns, few replacements and *proved* low-drilling costs. • We invite you to write for full information today.

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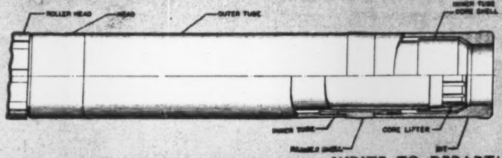
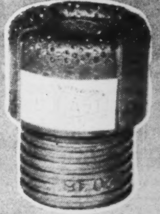
Sprague & Henwood, Inc., is also prepared to undertake Core Drilling by contract. This includes test boring or mineral prospecting and also foundation exploration for dams, bridges, buildings, etc. Drilling grout holes and grouting also performed on contract basis. Thoroughly experienced supervisors and operators available for contract drilling operations. Send us your inquiries for Core Drilling by contract.

NEW: A DOUBLE TUBE CORE BARREL—*For Better Core Recovery.* **The Series "M" Double Tube Core Barrel differs from others in that the inner tube is equipped with a shoe or case extending to the face of the bit and housing the core lifter. This reduces the tendency to block.**



"TRUCAST" BORTZ DIAMOND BITS—*Have Proved Their Worth:*



A mechanically set Bortz Diamond Bit which provides uniformity of contour and gauge. Can be furnished in all standard sizes and many special sizes as well. "TRUCAST" bits have been used in all types of diamond drilling for years and have well proved their worth.

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Stack Dum Dum Gives Lasting Protection to Concrete Stacks, Chimneys

Stacks and chimneys can't hide from the weather . . . they're vulnerable 12 months in the year! Stack Dum Dum's ability to defeat the hazards of severe weather conditions, high temperatures and extreme vibration has made it the leading preservative material of stack maintenance organizations.

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BRIDGES CRACKS—Eliminates the chief source of destructive surface deterioration.

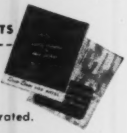
STAYS PLIABLE—Its elastic under-surface allows ample expansion and contraction to withstand cold or heat, and vibration, without cracking.

HEALS ITSELF—If outer surface is broken, under-surface heals at point of abrasion.

2 DUM DUM FOR METAL Its heavy film protects exposed metal surfaces against weather, fumes and gases. Stops rust and corrosion.

3 DUM DUM MASONOC Heavy film, not a paint, Dum Dum Masonoc's thick, tough, elastic coat gives many years added protection against the ravages of weather-wear.

WRITE TODAY FOR THESE VALUABLE BOOKLETS



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ARCo Maintenance Products

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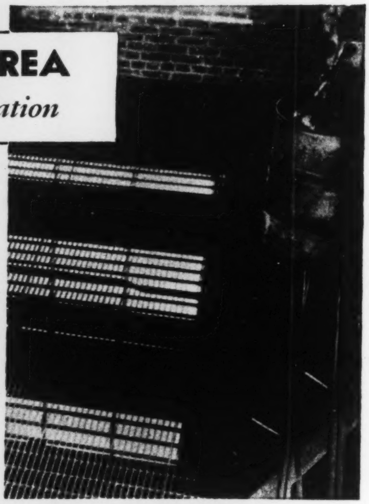

THE illustration shows the admission of light through three floors where the flooring is Hendrick Mitco.

Not only does pressure-formed Hendrick Mitco Open Steel Flooring have 90% open area, but there are no bolts, rivets or angle irons to collect dirt and refuse. The square-edge, uniformly spaced, rectangular steel bars provide a non-slipping, level walking surface. There is no lateral deflection, however heavy the loading, because each Mitco panel is a strong, integral unit.

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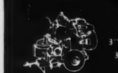

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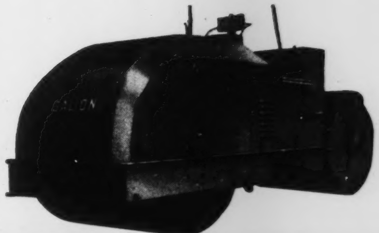

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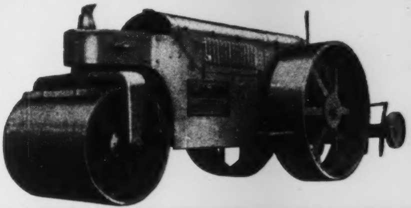

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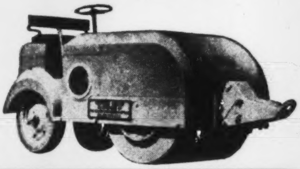

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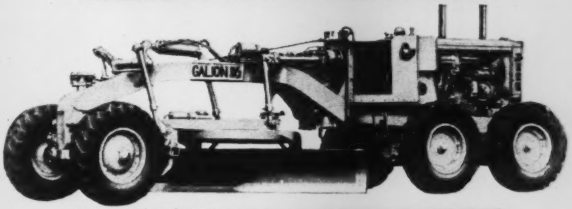

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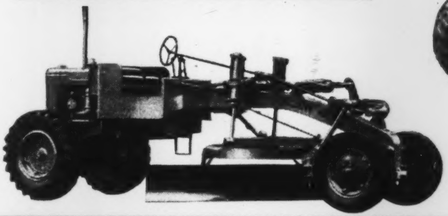

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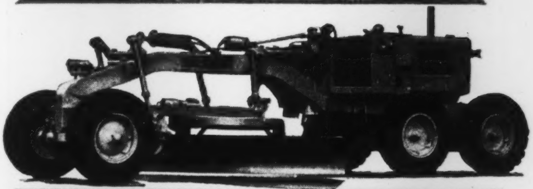

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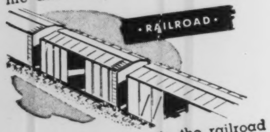
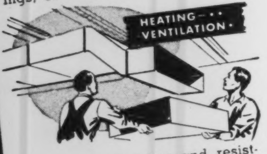


Galvanized products in the railroad industry guard bridges, cars, buildings, etc., against rust.



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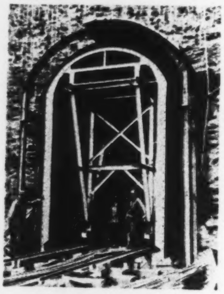

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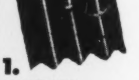

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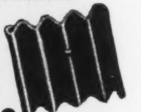

2. INTERLOCKING

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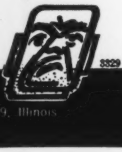

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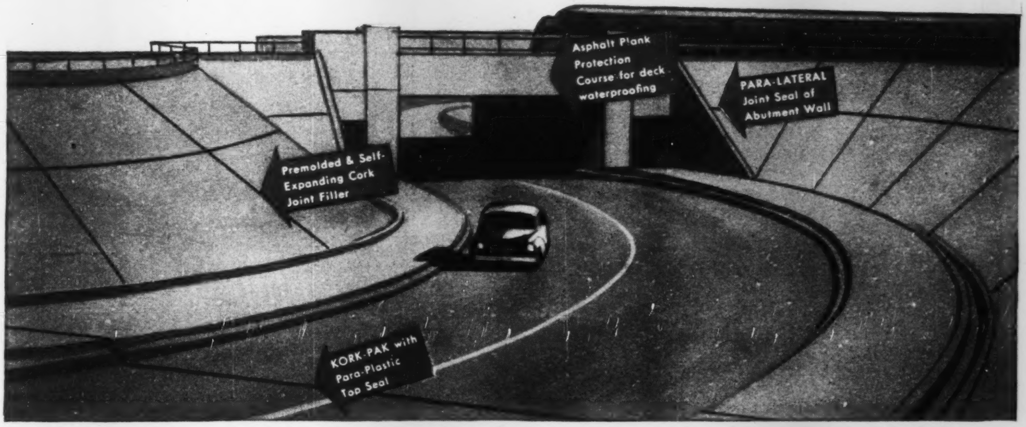

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- First inexpensive pre-molded asphalt joint filler.
- First and only manufacturer of pre-molded Para-Plastic for sealing overhead and vertical joints.
- First and only manufacturer of KORK-PAK Pre-molded Expansion Joint.
- First sponge rubber and cork rubber joint filler.

Engineers, architects and builders are invited to present their joint filling and sealing problems to us. Our experience as pioneers and leaders in the field of joint fillers and seals is at your service.

KORK-PAK
PREMOLDED PARA-PLASTIC

Write for illustrated circulars describing the Servicised line of asphalt, cork and rubber composition products for the construction industry.

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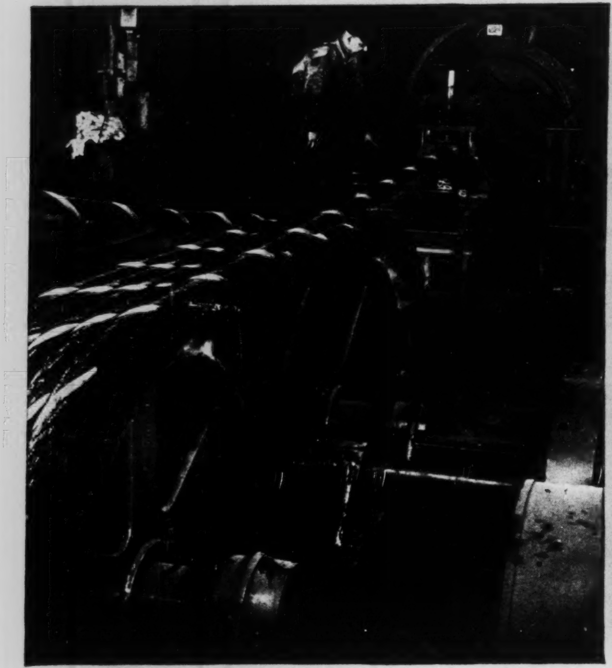
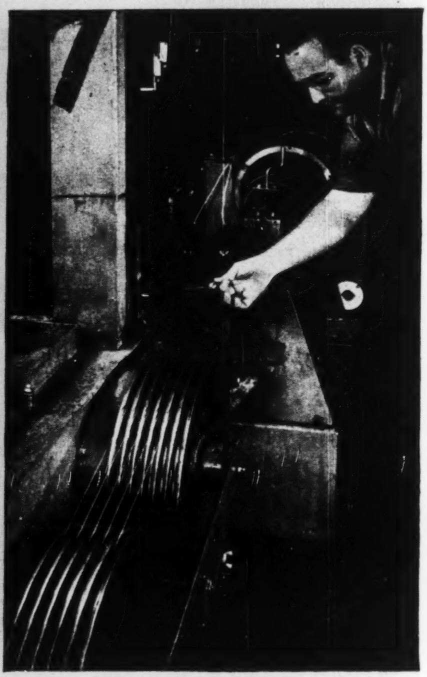
SERVICISED PRODUCTS CORP.
6051 W. 65th ST., CHICAGO 38, ILL.

This photograph shows a 3 1/8" diameter Monarch Whyte Strand Wire Rope coming off a Macwhyte closing machine. Weight of this rope is approximately 16.65 pounds per foot. It has a strength of approximately 392 tons and is used for the digging line on large dragline excavator with 35 cu. yd. bucket.



In this photograph is a 3/64" diameter Stainless Steel Cord coming off a Macwhyte closing machine. It weighs approximately 0.35 lbs. per 100 feet; has a strength of approximately 270 pounds, and is used for many small cord needs.



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LARGE WIRE ROPE or SMALL WIRE CORD

You will get smoother operation and better service when you use the wire rope designed and manufactured to meet your requirements.

Macwhyte engineers are always glad to suggest the correct Macwhyte rope or cord best suited to your needs.

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2930 Fourteenth Avenue **Kenosha, Wisconsin**

Manufacturers of Monarch Whyte Strand PREformed, Internally Lubricated Wire Rope, Atlas Braided Wire Rope Slings, Aircraft Cables and Assemblies, Monel Metal and Stainless Steel Wire Rope.

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a thousand and one
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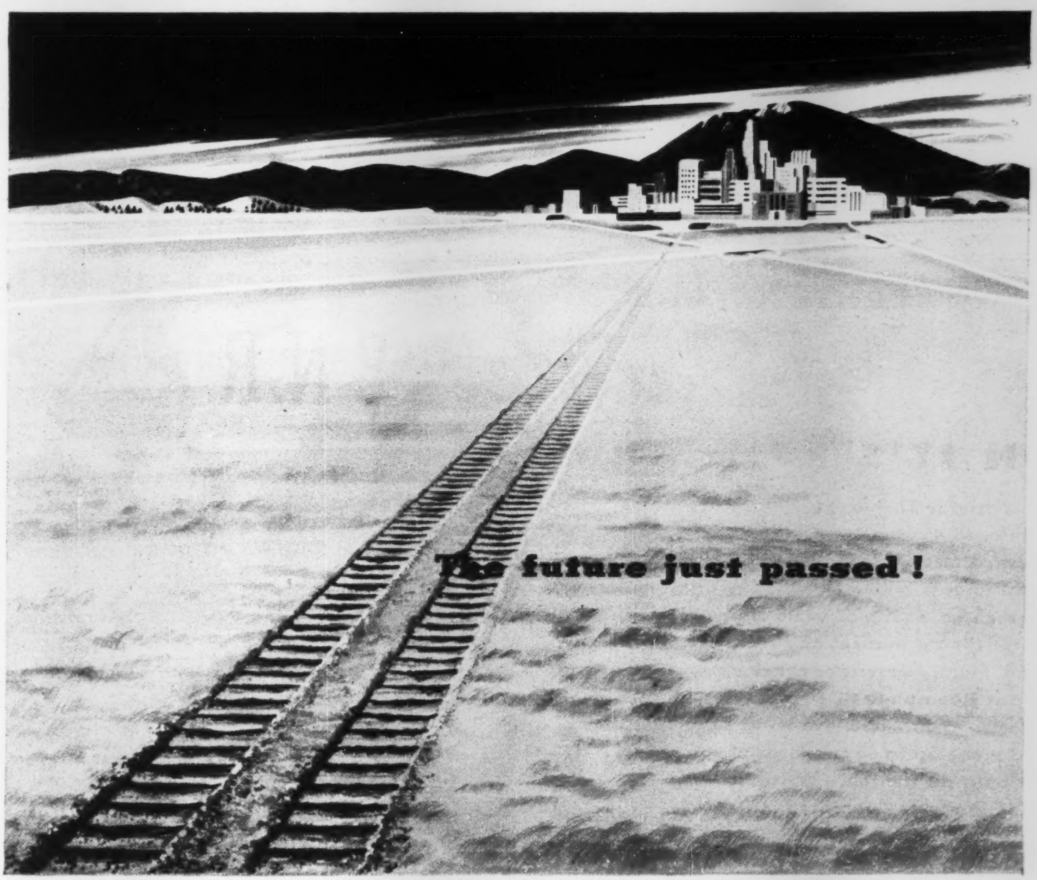
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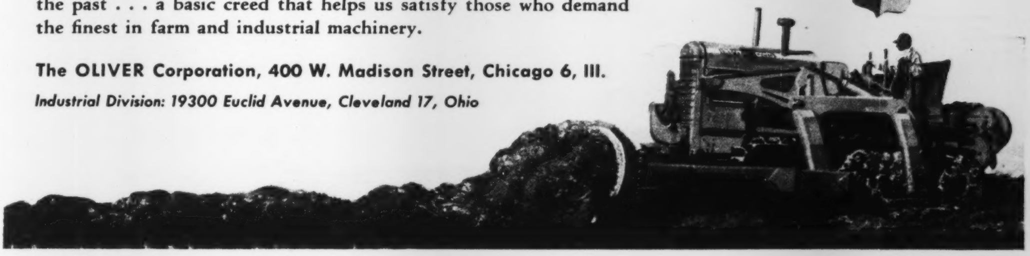

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ON IT'S 75th ANNIVERSARY

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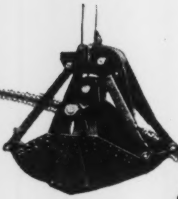
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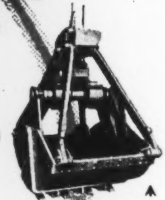
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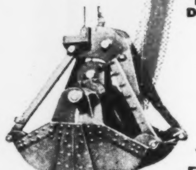
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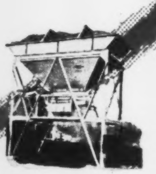
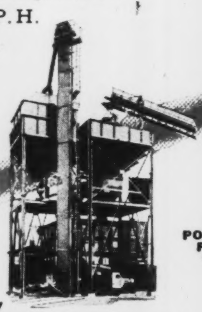
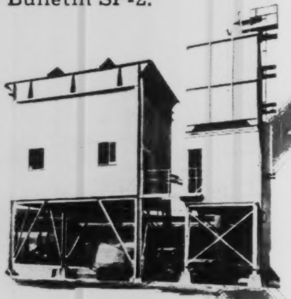
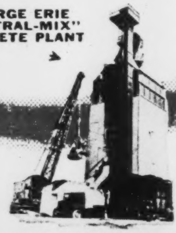

ERIE GA-36 YARD PORTABLE BIN


ERIE TYPE LA3 CEMENT BIN WITH ERIE CTC AGGREMETER PLANT

ERIE STRAYER PORTABLE CONCRETE PLANT CHARGING "TRUCK-MIXER"


ERIE TYPE CAB AGGREMETER PLANT WITH ERIE TYPE M CEMENT BIN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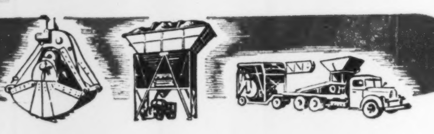

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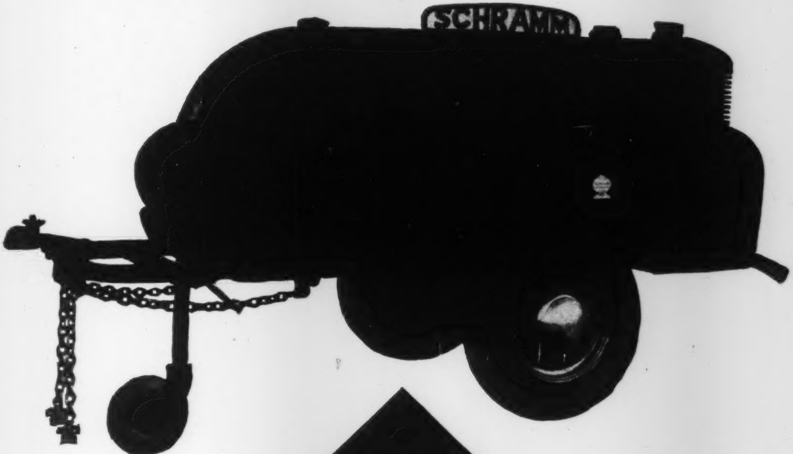

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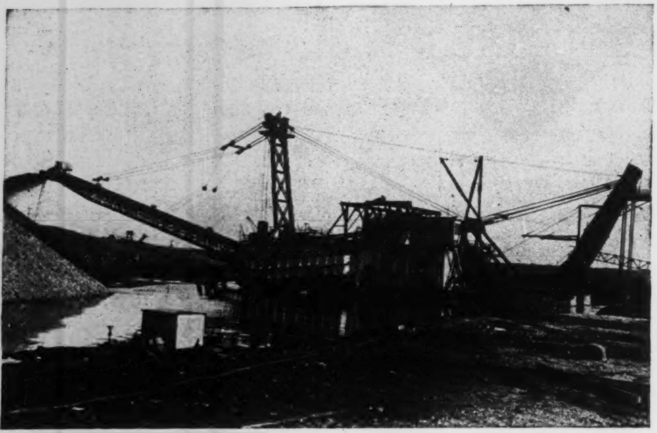

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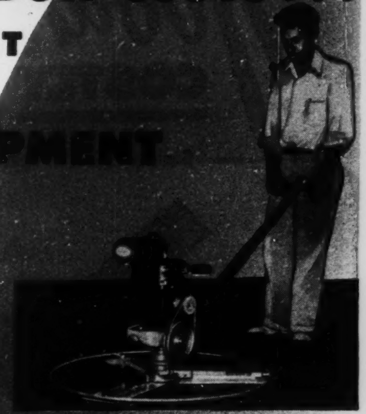

WHITEMAN FLOATING-FINISHING MACHINE
With "Snap-on" float trowels, brings up moisture and compacts the slab. Then, final finishes with tool steel finish trowels that can be adjusted for pitch while machine is in motion.

Labor is the biggest cost factor in construction today. Control it and you insure profits. And the easiest way to control labor costs is to use power equipment to increase the productivity of your men.

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WHITEMAN RODDING MACHINE
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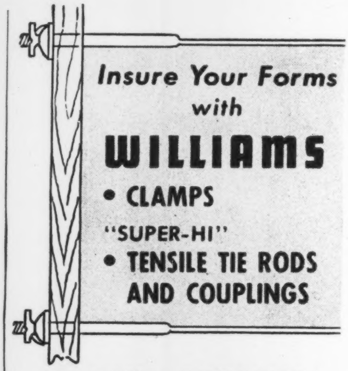

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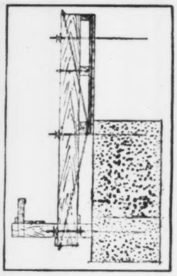
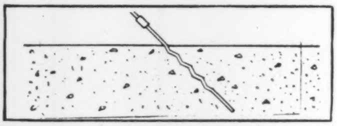
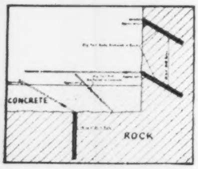


Williams originated the She-Bolt and Pig Tail Anchor (For details write for Catalogue No. 1600).

Williams She Bolt and Super-Hi Tensile Anchors on Cantilever Forms.



Super-Hi Tensile Pig Tail Anchors and Couplings in Mass Concrete.



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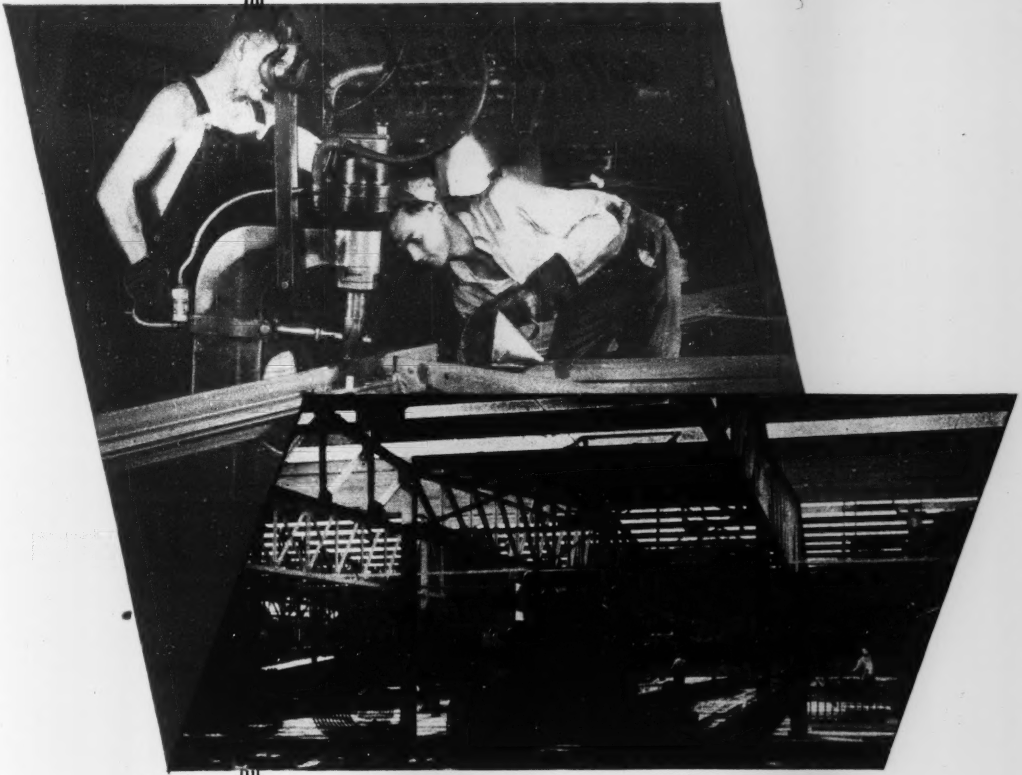

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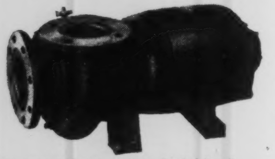

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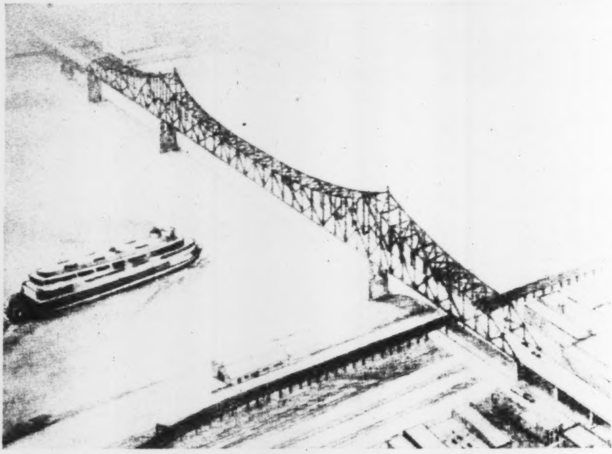

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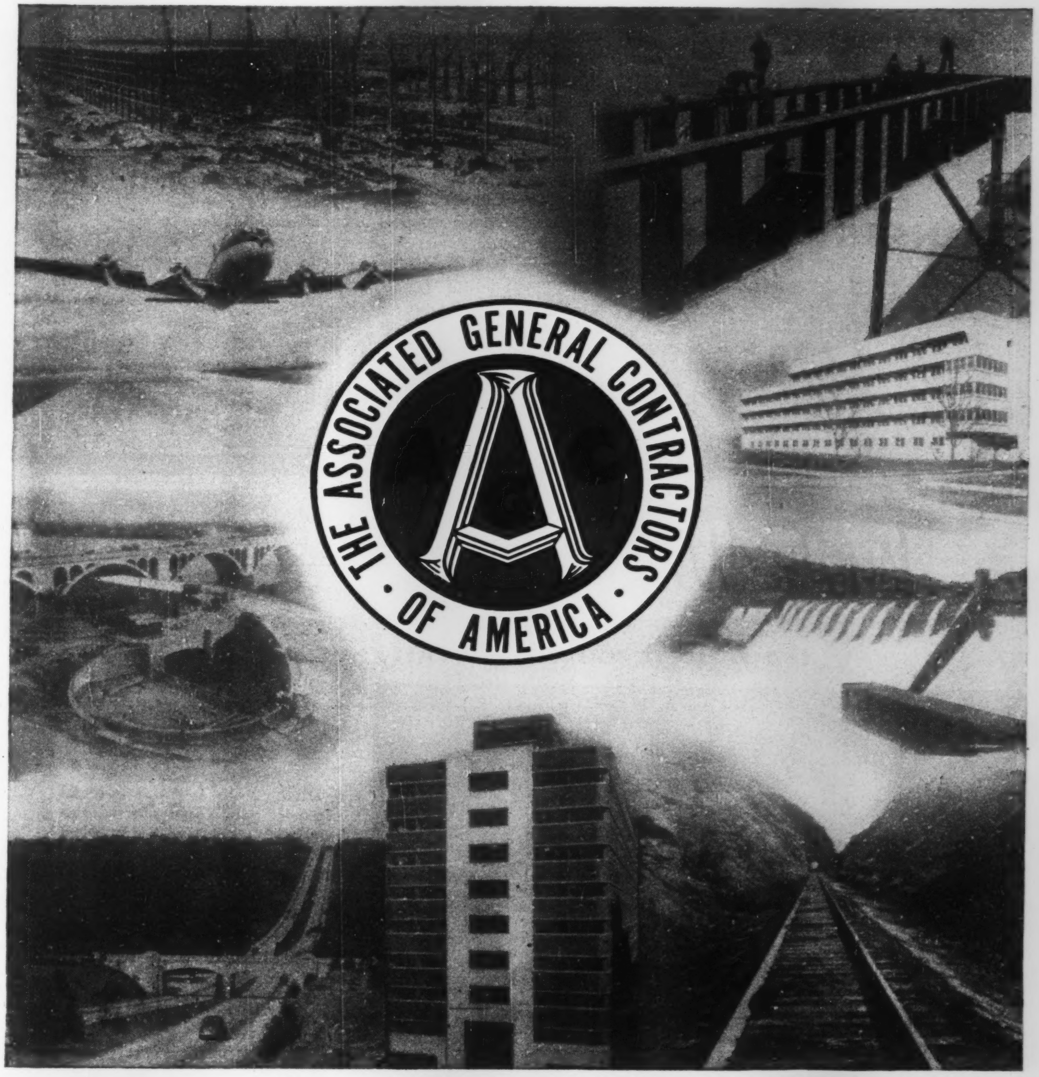
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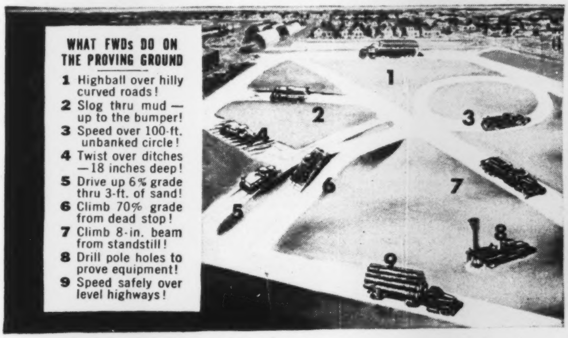

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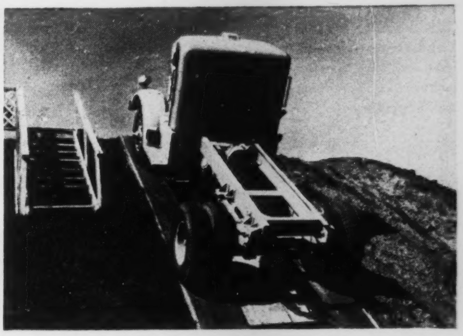
This is FWD's proving ground. This is your assurance that the FWD you select has the stamina to insure long life without expensive mechanical breakdowns.



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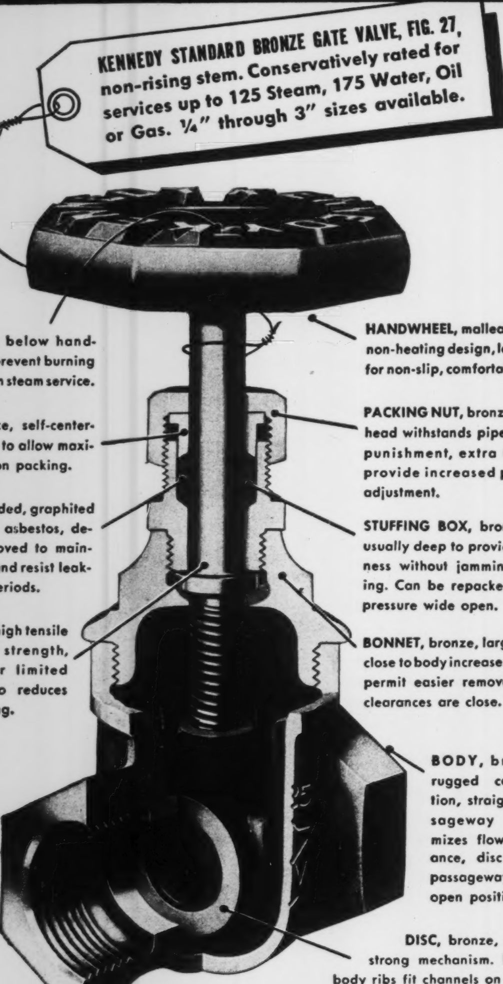
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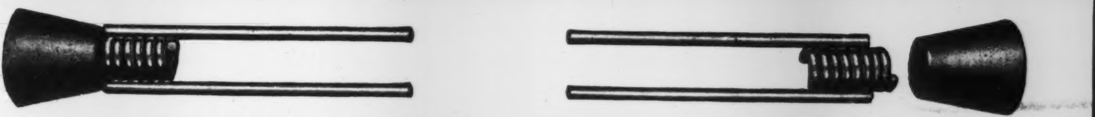

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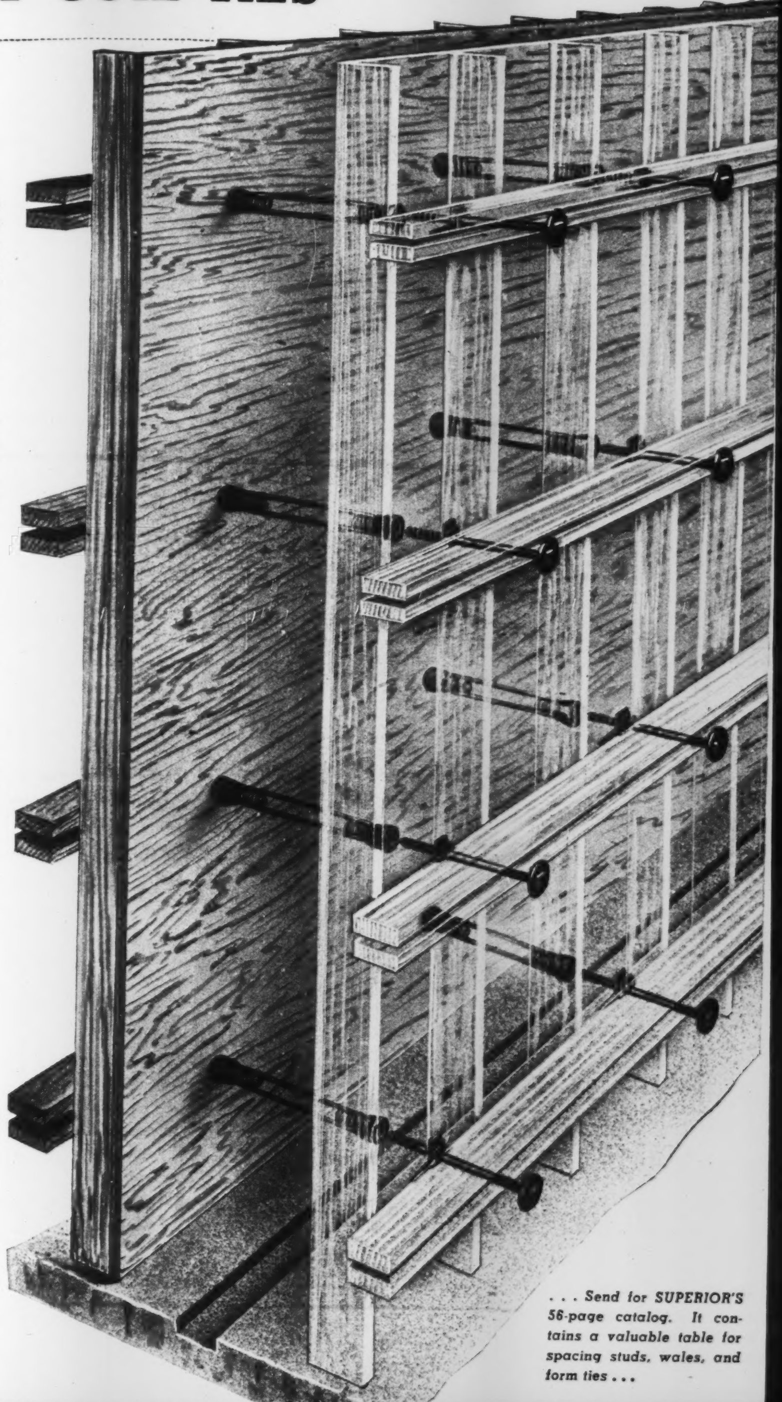

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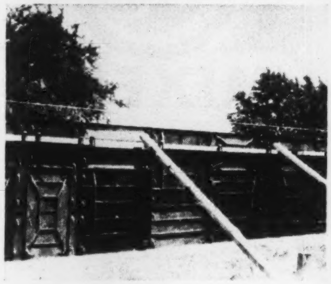

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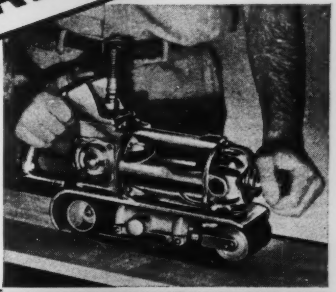

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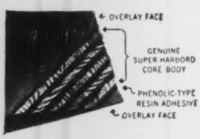

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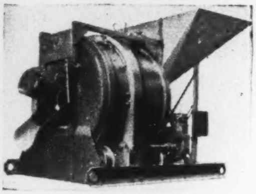

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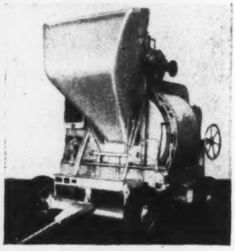

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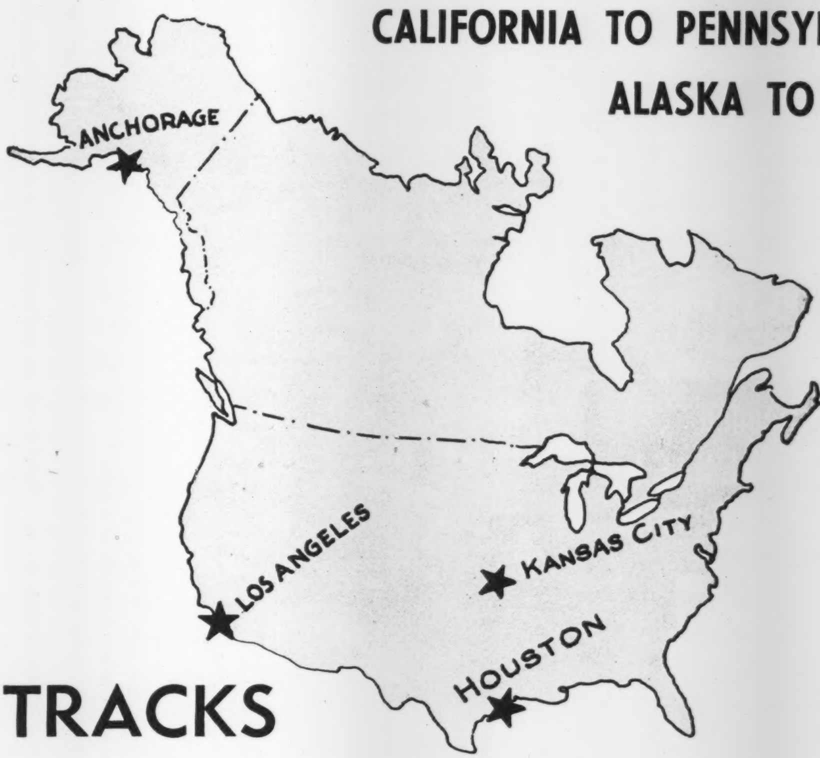
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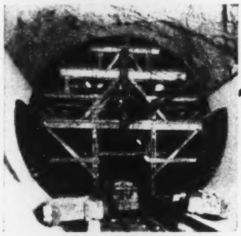

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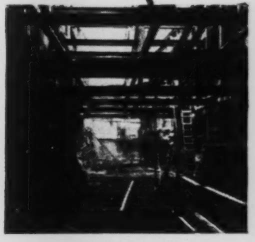

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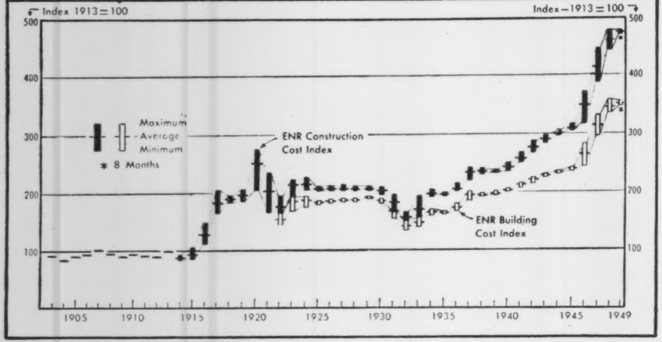
History and Use



Although ENGINEERING NEWS-RECORD began the systematic reporting of materials, prices and wage rates in 1909, it was not until 1921 that it established the ENR Construction Cost Index to measure the combined effect of wage and price changes on the value of the construction dollar. The most violent upheaval on record for construction prices had just occurred. Led by steel, prices had skyrocketed early in 1920, only to collapse in July. By the end of 1921, prices were down twice as far as they had shot up the previous year.

It was a time, certainly, when the need was great for an intelligence system, organized to detect and observe construction cost movements and trends.

ENGINEERING NEWS-RECORD published the ENR Construction Cost Index for the first time in the issue of July 21, 1921, pages 127-128. New values have been computed and published monthly since. A complete tabulation of these monthly values from 1914 to 1949, plus yearly values back to 1903, is a part of this article (see p 421).

What and why of ENR index

An index is a measuring device. It has been likened to a thermometer or steam gauge. As good an analogy—perhaps a better one—is the surveyor's system of measuring altitude from fixed bench marks. These altitudes can be determined according to how much they are above or below sea level, or they can be determined according to how much they are above or below a designated fixed local base, arbitrarily valued at 100. In either case, being related to a common known base, they are related to each other.

An index always measures the effect of two or more variables working in combination. Degree and direction of change in a single variable are shown by straight percentages or relatives. The problem becomes more technical, however, when you want to know the combined effect, say, of board feet of lumber, tons of steel, barrels of cement and man hours of labor.

This calls for an index. It caused the ENR Construction Cost Index to be developed.

This index was designed as a general-purpose construction cost index that would measure the basic groundswells in construction costs. It is a weighted aggregative index with a fixed base, made up of selected quantities of construction materials and labor, multiplied by their actual prices. It was constructed so that its base is a hypothetical block of construction that cost $100 in 1913.

This block was made up of four dominant elements of construction in the following amounts:

			%
25 cwt. of steel at	$1.50	$37.50	38
6 bbl. of cement at	$1.19	$7.14	7
0.6 Mft bm of southern pine at	$28.50	$17.10	17
200 man hours of common labor at	$ 0.19	$38.00	38
Index base, 1913		$99.74	100

Because the index was designed to indicate the basic underlying trend of construction cost in the United States, construction materials were used that were least influenced by purely local conditions. These mate-

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rials—steel, cement and lumber—were also selected because they promised the most stable relation to the whole economy and to its price structure. Any material that might go partly or wholly out of use would obviously jeopardize the future of the index.

A second basic requirement was to arrive at a correct balance of the relative importance of the four elements in the index, that is to fix its "weighting." For this purpose, total U. S. annual production of steel, lumber and cement was examined, plus the number of common laborers, exclusive of farm workers.

Total production and non-agricultural common labor were taken, instead of only the amount of steel, lumber, cement and labor used on construction work, because construction operates within the whole economy and not just in its own segment of it. In the case of steel, for example, even if it had then been possible to segregate from the total the amount used on construction, an indeterminable error would have been introduced by using the latter. Construction cost is influenced directly or indirectly by the cost of machinery and tools, by the demand for armor plate and rails and by the export demand. It was, therefore, desirable to take into consideration the entire production. The same was true in lesser degree for lumber and for cement.

As to labor, its shift from one industry to another was of such nature as to necessitate considering the total for common labor (exclusive of that on the farm) in determining the part it played in construction cost.

The years 1913, 1916 and 1919 were selected to secure figures for materials production. The average production of steel for these years was about 33,000,000 tons; for cement, 90,000,000 bbl.; for lumber, the average production of 1913 and 1916, according to government figures, was 42,000,000 M ft. b. m. The number of common industrial laborers (1910 census) was 4,000,000. These amounts of materials and labor were then multiplied by 1913 prices, with the result shown in the following tabulation. This also shows the percentage relation to the whole for each element. Thus:

		%
33,000,000 tons steel at $30.00	$990,000,000	24.2
90,000,000 bbl. cement at $1.19	107,100,000	2.6
42,000,000 M. ft. b.m. lumber at $28.50	1,197,000,000	29.2
1,200,000,000 man days at $1.52 (8 hr.)	1,822,000,000	44.0
	$4,116,100,000	100.0

Prices used were 1913 average for

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structural steel, Pittsburgh base; ("Pittsburgh-plus" pricing then was in effect in steel); Cement, net bbl., fob Chicago, exclusive of bags; lumber, New York base (3x12 to 12x12) southern pine; labor, rates paid blast furnace laborers (ENR construction common labor rates, not available prior to 1921, were used thereafter).

It will be noted that the percentages tabulated above, representing roughly the actual total "use" of the four elements in a selected average year, are not the exact percentages chosen for the index. The differences represent the "weighting," which was arrived at by judgement, based on a careful analysis of the relative importance of the elements in construction, in turn based on the opinions of many experienced construction authorities.

Index kept simple

The decision to keep ENR Construction Cost Index so simple was based on this reasoning:

a. The three materials selected were (and still are) governing cost factors because of their predominating use in construction. Their continued importance was also assurred since none was likely to go out of use.

b. Price movements of all three are either national or broadly regional in scope, and applicable to general construction throughout the country. They also promised a representative relation to the price structure of the overall national economy.

c. Reliable price quotations were (and still are) available promptly for all three so that the index can be computed swiftly, giving it maximum timeliness. This means that changes in price movements and overall trends are detected as soon as they occur and when the knowledge of them is most useful.

d. While there might be some weaknesses in an index based on a small number of components, it was felt that the greater the number of elements to be priced, the greater the time lag would be between verifying correct prices and releasing the computed index. Also, and an important consideration, the more elements to be priced, the more expensive the index would be to maintain, and the greater the danger of its collapsing of its own weight.

e. Finally, an index made up of fewer elements or components is more sensitive than one made up of many.

In the 28 years since the ENR Construction Cost Index was established, four minor modifications have been made to meet changing conditions in the materials and labor markets as follows:

LUMBER: In 1936, the price of 12-in. long leaf yellow pine timbers, used in the index, was replaced by a composite 20-cities price average of 2x4 Douglas fir and southern or local pine, S4S, carload lots. The weighting given to lumber was adjusted on the basis of 1936 averages, and on the difference in price level of the old and new lumber price series, so that the 1936 ENR Construction Cost Index value average would not be changed. The weighting thus changed from 0.6 M bd. ft. 12x12 LLYP at New York City to 1.088 M bd. ft., ENR 20-cities composite average price for southern pine and Douglas fir 2x4 S4S.

The only long-time lumber price records available are based on long leaf yellow pine. In the 1930's, however, price quotations for 12x12 size in this species did not reflect an active market. In fact 12x12 LLYP timbers disappeared from the market.

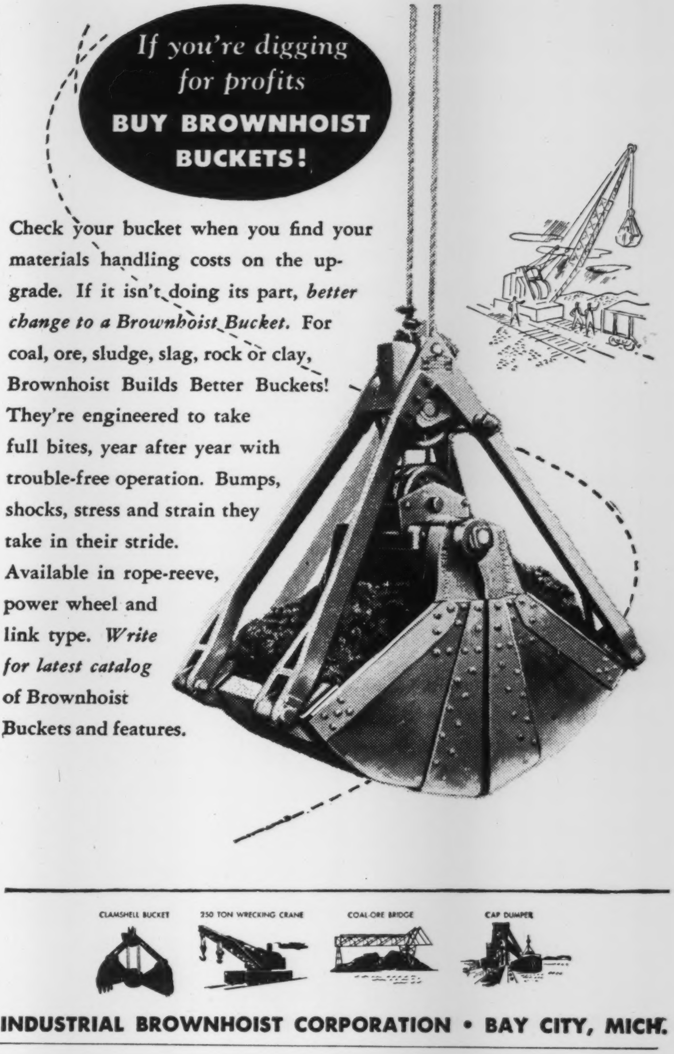
The 20-cities, 2x4 fir and pine lumber price series was selected with the advice of the lumber associations as the best to reflect an active market and give a superior measure of national movement in lumber prices.

To test the effect of this substitution, both lumber series were computed and reported for an overlapping period of three years, 1935-'37. These are shown in the accompanying table.

Splicing in New Lumber Series
(Overlapping Calculations)
ENR Construction Cost Index—1913 = 100

	Using 12x12 LLYP			Using 2x4 S4S Douglas fir and southern or local pine		
	1935	1936	1937	1935	1936	1937
J.	198.72	199.48	223.45	198.22	201.23	221.20
F.	196.02	201.20	223.45	195.07	201.33	222.05
M.	194.26	201.20	225.25	194.41	201.63	224.75
A.	194.50	202.20	230.25	194.65	202.80	231.35
M.	194.06	203.40	233.25	193.96	204.05	233.45
J.	194.78	204.60	238.15	196.73	205.08	237.25
J.	195.18	204.40	241.75	197.43	204.80	239.90
A.	195.10	208.10	242.95	197.45	208.48	240.65
S.	195.10	208.10	243.95	197.30	208.88	241.62
O.	195.10	211.50	244.55	197.50	211.53	241.90
N.	194.90	212.70	244.95	197.35	211.50	241.40
D.	194.90	220.05	244.95	197.20	215.70	241.05
	195.22	206.41	236.41	196.44	206.42	234.71

STEEL: In 1938, Pittsburgh "plus" pricing of steel was ruled out. A weighted average of steel prices at Pittsburgh, Gary and Birmingham (based on relative shipments from the three mills) was substituted for the old Pittsburgh mill price series, effective with the August, 1938, ENR Construction Cost Index. No change in steel component weighting was necessary.



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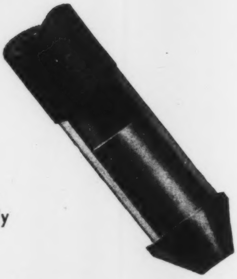

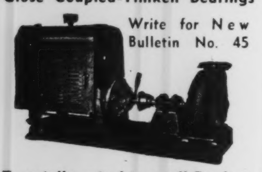

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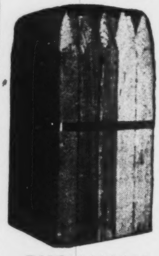

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1x2—24"	6.20	5.65
1x2—36"	8.80	8.00
2x2—12"	6.50	5.90
2x2—15"	8.15	7.00
2x2—18"	8.70	7.90
2x2—24"	10.45	9.50
2x2—36"	15.00	3.65

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CEMENT: In mid-1948 cement went off basing point pricing with considerable readjusting in cement prices in areas distant from mills. An average of bulk cement prices, in the 20-cities for which ENR quotes prices, proved so close to the Chicago cement price hitherto used in the index that the new 20-cities average was adopted in July, 1948, without any change in weighting.

LABOR: The original use of common labor in the construction cost index was based on the belief that it set the trend for all wage rates. Actually during the first world war, again during the "pump priming" days of the Thirties and again after the second world war, common labor wages climbed much faster percentagewise than did skilled wages.

To measure the effect of this divergence between common and skilled wages, ENGINEERING NEWS-RECORD in 1938 established the ENR Building Cost Index in which the labor component is based on the ENR 20-cities series for skilled labor wages —an average for carpenters, bricklayers and iron workers.

To establish the weighting for labor in the ENR Building Cost Index, the ENR skilled wage average for 1913 was divided into the labor component of the ENR Construction Cost Index for 1913. This gave the number of hours, 68.38, for weighting skilled labor to a Building Cost Index base of 100 for 1913.

Recheck of weightings

A number of users of indexes have assumed (incorrectly) that the ENR cost indexes were based on the quantities of materials used in construction in 1913. In this belief they have asked if these original weightings should be adjusted to quantities of materials now used. Actually the base used was broader, economically, than the above assumption. Even so, it will be well to examine what has happened to the relative positions of these components while their amounts remained fixed but their prices changed.

Using all steel production, all Portland cement production, all lumber production, all non-agricultural workers, and pricing them in 1913 (original base), 1933 (depression low) and 1948 (postwar peak) prices, the following ratios result.

	1913		1933		1948	
	Theoretical Base	Actual ENR Constr. Cost Index	Theoretical Base	Actual ENR Constr. Cost Index	Theoretical Base	Actual ENR Constr. Cost Index
Steel......	24	38	20	24	22	16
Cement....	3	7	3	6	2	4
Lumber....	29	17	18	17	24	22
Labor.....	44	38	59	53	52	58
Combination.....	100	100	100	100	100	100

When the index was designed in 1921, students of prices believed that as steel goes so goes the nation, that steel prices controlled or dominated all prices. For this reason the steel weighting in the index was increased.

Today, most observers will agree that labor's wages have taken over this controlling position in price movements. And, as the above tabulations show, this situation is reflected by the index. In effect it has moved with the times.

A second test—pricing only structural and reinforcing steel shipments, all Portland cement, 65 percent of all lumber production and the BLS estimate of contract construction labor—shows these ratios:

	Theoretical Base	1933 Actual ENR Constr. Cost Index	1933 Actual ENR Bldg. Cost Index	Theoretical Base	1948 Actual ENR Constr. Cost Index	1948 Actual ENR Bldg. Cost Index
Steel	21	24	27	17	16	21.5
Cement	6	6	7	5	4	5
Lumber	26	17	19	32	22	29
Labor	47	53	47	46	58	44.5
Combination	100	100	100	100	100	100

Considering that the concrete aggregates, rock, sand, gravel and the great yardages of excavation are not represented in the above "construction" materials quantities, the high labor ratios appear to be fully justified. Competing with lumber today are new products not existing in 1921 (plywood and the various building boards). Since these are not represented in the index directly, lumber can well carry more weight in the index than justified by its own production alone. Steel and cement may have receded too far in their relative influence, and lumber advanced too much, but not enough to justify the obvious major disadvantages of weight changing mid-stream.

The ENR Construction Cost and Building Cost Indexes measure trends in basic costs of construction materials and labor without any correction up or down for low or high productivity of management and labor on the construction job. In times when this productivity is low, as in postwar periods, selling prices of construction (as represented by contractors bids or final costs of structures in place) will be relatively higher than the index.

At the other extreme, during a depression, when productivity is high and bidding competition painfully sharp, the selling price of finished construction will pull down below the material and labor cost trends measured by the ENR cost indexes.

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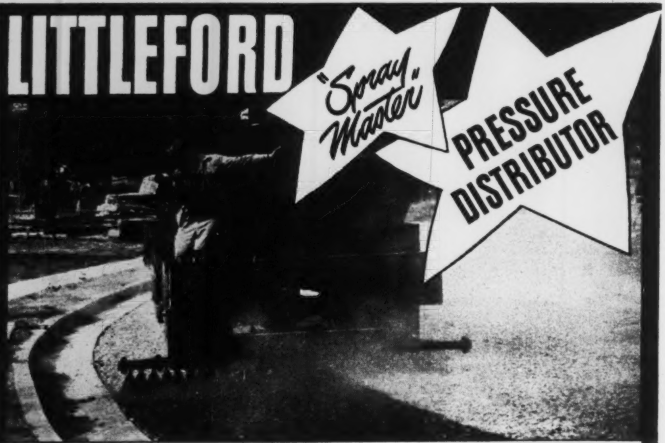

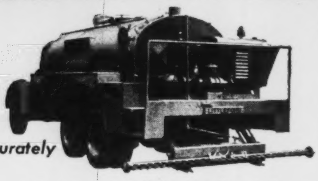

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changes are less extreme, these indexes have established a long history of accuracy in predicting degree as well as direction of change.

Special purpose indexes exist which measure construction selling prices. More are needed. The extent to which these vary above or below the ENR Construction Cost Indexes gives a rough measure of construction productivity.

The value of a cost index is measured by how much use is made of it. Examples are given beginning on p. 406 of the uses on record that are made of the ENR Construction and Building Cost Indexes. First, however, the paragraphs that follow immediately give a quick review of what elements to consider in using a cost index. They show also how these elements apply to the ENR Cost Indexes.

Types of indexes

Some indexes are founded on absolute values, specified quantities and actual prices. These are the aggregative indexes, some unweighted, some weighted. The ENR Construction and Building Cost Indexes and most other construction cost indexes are weighted aggregative indexes, constructed with actual quantities, priced and repriced. This type of index has the advantage that the base year can be shifted at will, 1913—100, 1926—100, 1939—100, for the quantities or weightings are the same in each year. It is a direct type of index, and has a simple, clear meaning.

Some indexes are averages of relatives, some unweighted, some weighted. This type of index is constructed by reducing each variable to a percent of some common base and averaging these percentages. The building cost index published by the Construction Division, Bureau of Foreign and Domestic Commerce, Department of Commerce, is of this type. It averages seven building and construction cost indexes to get its "composite" index.

Bases' used

In constructing either of these two basic types of indexes, two types of bases are used:

1. *Fixed*, where quantities and weightings, once adopted, remain constant. Most construction cost indexes are of this type.
2. *Chain*, where the base is changed each month, or quarterly or annually.

The ENR Cost Indexes are converted to this type in Engineering News-Record's Monthly Construction Business Summary page, where percent change from last month and from last year are reported. These are not available, however, in tabular form.

In selecting an existing index for use, or in constructing a new one, the following factors should be known and understood:

Purpose. A general purpose series may serve many functions. The Engineering News-Record Construction Costs Index is a general purpose index, and examples of its use are reported in the following pages. Other indexes are designed to serve one special purpose. One example of this type is the composite-mile highway bid price index of the U. S. Bureau of Public Roads. Others include the industrial building cost indexes and the small house construction cost indexes.

Base period. In the base period used, conditions should be as normal as possible, data needed should be available for that and subsequent years or periods, and the period selected should be comparable to that of other related indexes. In a fixed base, aggregative index, such as the ENR Construction and Building Cost Indexes, the base year or date can be shifted at will.

Base value. The most usual base value is 100. This is purely for convenience sake so that percentage change from the base period can be determined directly without additional calculations. In Australia, 1000 is used. In his cost index for a typical manufacturing plant, E. Warren Bowden, vice president, Walter Kidde Constructors, Inc., used $3 per sq. ft. of floor area in 1939 as a base (ENR April 17, 1947, page 101). Subsequent index values read directly in cost per sq. ft. of floor, rather than in the abstract 100 ratio or percentage change.

One of the advantages cited for the 100 base is that trends can be reported without disclosing actual amounts. Turner Construction Co., for example, Aberthaw, or Austin, in their cost indexes, can show what the trends are in their costs without disclosing what the actual costs are.

Components should be representative, should be readily available so that accurate price quotations can be obtained and should be weighted as to relative importance.

Weighting can be by base period quantities. This is the simplest, and most construction cost indexes use this method.

Other methods include: a. weight-

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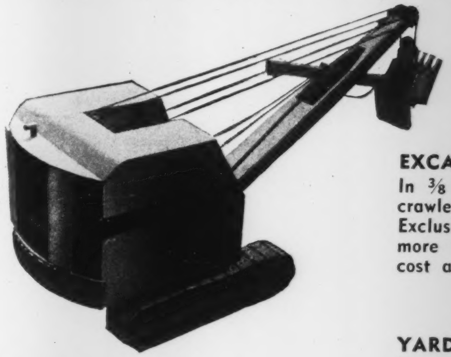

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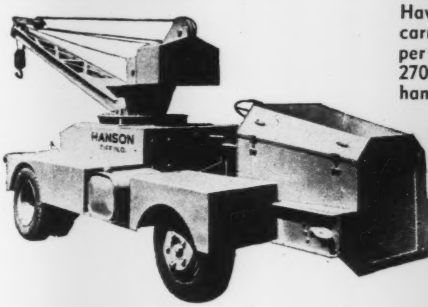

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ing by quantities at given periods, and changing weights monthly, annually or on other periodic schedule; b. by averaging quantities of the base year with each subsequent year; c. by averaging quantities for several years considered typical; d. by averaging quantities for all years included (not practical for a continuing index); e. by making two indexes, each with a different set of weights, and averaging them.

Wesley C. Mitchell, in U. S. Labor Statistics Bulletin 173, reports that it is very desirable to publish price quotations and weights used so that those who use the index can adapt it intelligently to their needs, and know what they are doing.

ENR Construction Volume Index

The first use that is made of the ENR Construction Cost Index is to compute the ENR Construction Volume Index, to derive physical volume of construction from the dollar volume figure.

The most practical way to measure overall construction activity is in dollars, the only common denominator of all construction. But when construction costs more in some months or years than it does in others, a true comparison of physical volume can only be made by adjusting dollar volume to allow for this change in cost or in the value of the construction dollar.

The ENR Construction Volume Index was established to measure this rise and fall in physical volume of construction. This is done by dividing the weekly average of engineering construction contracts awarded during a given month by the ENR Construction Cost Index. This adjusts current dollars to 1913 dollars. Then, to reduce to a volume index base of 100, the 1913 dollars figure is divided by the weekly average volume of construction in 1913.

Both the dollar volume of engineering construction as reported by Engineering News-Record and the ENR Construction Volume Index are shown in the accompany table bottom of this page.

In addition to the volume in dollars, dollar volume relatives are shown with 1913 as 100. These are unadjusted for changes in value of the construction dollars. They show, in direct comparison with the volume index, what happens to physical volume when costs go up.

In 1929 for example when dollar volume was 657 percent of 1913, physical volume was only 317 percent. And in 1948 when dollar volume was 1200 percent of 1913, up 1100 percent, physical volume was only 254, up 154 percent.

One of the practical uses of the ENR Construction Volume Index is to compare tons of structural or reinforcing steel or barrels of cement shipped with physical volume of engineering construction. By observing the correlations of the past, the needs of the future can be gaged. The volume index is computed each month, and is second only to dollar volume as the earliest of the construction activity indicators to be made available to the reader.

The ENR Construction Cost Index can also be used for measuring construction activity in construction dollars of comparable value without going all the way to a volume index base.

For example, construction volume can be measured in 1939 dollars, or in 1929 or in 1913 dollars. All that is necessary is to divide the current dollar volume by the current value of the ENR Construction Cost Index, then multiply by the Cost Index value for the control year. To get 1948 volume in terms of 1939 construction dollars, for example, divide 1948 dollar volume of construction by the 1948

Engineering Construction Volume as reported by Engineering News-Record

	Construction Volume in Dollars	$ Volume Relatives (no adjust. for costs)	ENR Constr. Volume Index 1913 = 100
1913	$601,405,000	100	100
1914	582,884,000	97	107
1915	584,874,229	97	100
1916	933,334,600	155	119
1917	739,101,814	123	67
1918	992,743,768	165	86
1919	1,175,888,000	196	98
1920	1,523,076,000	253	99
1921	1,193,510,000	198	96
1922	1,556,592,000	258	147
1923	1,904,040,000	317	146
1924	1,999,290,000	332	154
1925	2,559,443,000	426	201
1926	2,853,842,000	475	228
1927	3,253,766,000	541	263
1928	3,578,580,000	595	287
1929	3,950,315,000	657	317
1930	3,173,259,000	528	260
1931	2,432,314,000	404	220
1932	1,219,309,000	203	127
1933	1,068,369,000	178	102
1934	1,360,596,000	226	114
1935	1,590,151,000	264	134
1936	2,386,845,000	397	185
1937	2,437,623,000	405	172
1938	2,791,931,000	464	197
1939	3,002,856,000	499	211
1940	3,987,243,000	664	269
1941	5,868,699,000	976	375
1942	9,305,829,000*	1547*	553*
1942	8,005,829,000	1331	482
1943	3,061,844,000	509	176
1944	1,729,753,000	288	96
1945	2,289,408,000	381	123
1946	5,176,034,000	844	250
1947	5,659,232,000	941	228
1948	7,219,387,000	1200	254
1949 (7-Mo.)	4,579,411,000	751	275

*Contracts awarded, of which $1,300,000,000 was cancelled by orders of War Production Board.

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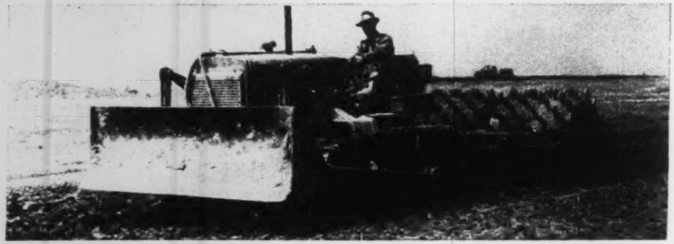

Photo by courtesy of Caterpillar Tractor Co., Peoria, Illinois

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ENR Construction Cost Index and multiply by the 1939 ENR Construction Cost Index.

How others use ENR indexes

Many and varied uses have been made of the ENGINEERING NEWS-RECORD Construction and Building Cost Indexes by contractors, engineers, architects, accountants, insurance companies, bankers, public officials, and corporation financial executives.

Examples on record include the following:

- **For cost estimating**—Cost estimating—of prime interest to engineers, architects, and contractors, as well as to insurance, legal and financial interests involved in construction—is always a process of proceeding from the known to try to guess the unknown. Cost indexes help to improve that guess work and to limit its range of possible error.

Cost indexes are invaluable for rough, speedy, preliminary estimates. They are useful for testing the overall results of detailed, precise estimates to catch possible omissions or excesses.

They are widely used by engineers to judge the reasonableness of contractors' bids before awarding contracts.

One method of organizing such cost estimating is described by Thomas H. McKaig, consulting architectural engineer, Buffalo, N. Y. He writes, in a service bulletin to his clients:

"One office for whom I work, has plotted on a long sheet of cross section paper, the ENR Cost Index over a period of years, and opposite the bid date of each job they have written the name of the job and the cubic foot or square foot cost. Then by comparison of cost indices of today against the date of the former job, the new job can be brought immediately to today's prices."

An eminent consulting engineer in Boston writes "For a number of years employees and associates of Chas. T. Main, Inc., have been using your construction and building cost index numbers for estimating."

The engineer of location and design, Division of Construction, Department of Public Works, State of New York, writes, "This Division has used your Construction Cost Index as a basis for comparing highway engineering estimate costs for the past several years."

Plant engineers in large industrial companies are called upon, often on short notice, to estimate what a new plant would cost. Construction cost indexes are widely used to project known plant construction cost of a given date to cost levels prevailing at the time for which a new plant estimate is needed.

Detailed cost estimates are both expensive and time consuming. Once made they need to be adjusted to changed conditions if they are to be used at a later date.

For example, L. G. Lenhardt, general manager, Board of Water Commissioners, City of Detroit reports: "This Department has found the ENR Construction Costs Index to be exceedingly valuable. We use it particularly in revising cost estimates on the multitude of postwar projects for which plans were prepared in the preceding five years. I have noticed that other city departments have also used these data for the same purpose."

Both Illinois and Michigan passed laws during World War II to give state aid to local communities to help them finance plans for public works to be built after the war's end. All costs were to be estimated at 1940 averages. The method for adjusting these estimates to future conditions is quoted below from the manual of procedures of the Michigan Planning Commission:

"The average costs for 1940, as established by the local building or construction industries, plus the percent of increase in the average cost indexes for such industries for 1943 over 1940 as established by the Engineering News-Record, shall be used to determine the construction cost estimate for projects and fees to be paid for professional services furnished on a contractual basis. These fees shall also serve as a guide in determining the grants to be made to applicants performing the work by their own forces."

• To demonstrate need for funds—Outside, impartial, evidence of cost movements is very useful in demonstrating need for additional funds or showing what happened to available funds. For example, in the annual report of U. S. Steel Corp., Enders M. Voorhees, chairman, finance committee, states:

The cost of replacing existing tools and adding to plants and facilities continues to increase. For example, a new cold reduced sheet mill, authorized late in 1945 at an expenditure of $25,250,000 to expand capacity, is currently estimated to have a final cost of $43,220,000, or 71 percent more than planned. Again, additional tin plate capacity, authorized late in 1945 at an expenditure of $13,250,000 is currently estimated to have a final cost of $19,542,000, or

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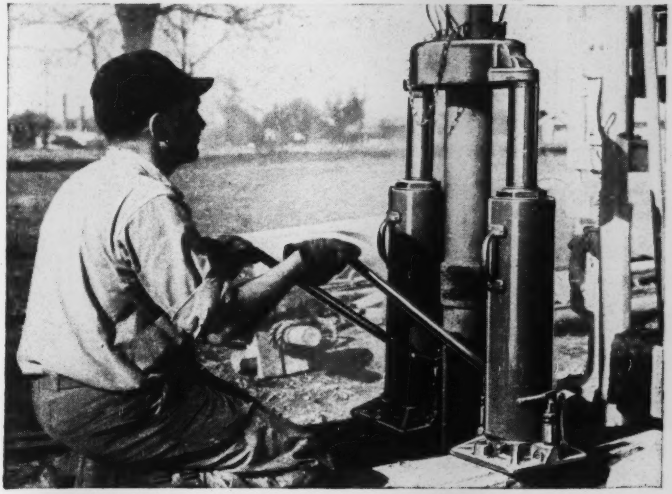

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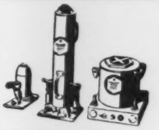

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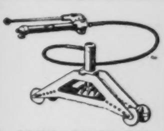

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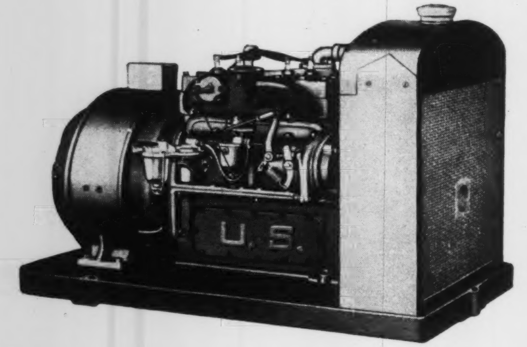

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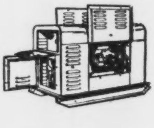

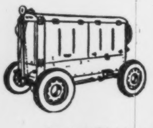

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47 percent more than planned. The increase over 1940 in construction costs, as measured by the Engineering News-Record index, has been as follows: Five war years, 18 percent; 1946, 43 percent; 1947 68 percent."

A construction engineer with the United States Public Health Service writes:

"Being employed as an architectural engineer in the Division of Hospital Facilities of the U. S. Public Health Service it becomes necessary for me to demonstrate during staff meetings to the medical profession in the P. H. Service in visual form the increase in cost of hospitals to be constructed under the Hill-Burton Act, Public Law 725.

"I should appreciate it therefore to receive from you a copy of your graph, 'Comparison of Building and Construction Cost Indexes,' and of other groups in regard to rise of labor and material cost, and of commodity costs (corn, wheat, etc.) suitable for visual demonstrations."

One of the staff engineers employed by the Bureau of Highways, Department of Public Works, State of Idaho, reports:

"Our Biennial Report for the period ending June 30th last is in preparation, and we are very desirous of using therein the 'Construction Cost Index Graph' which appeared on page 108, May 27, 1948, issue of your magazine. We are very anxious to use this construction cost index curve in connection with our 'State Raised Revenue' curve, and thereby show that construction costs have risen in proportion to our revenue."

Louis R. Howson of Alvord, Burdick and Howson, consulting engineers, Chicago, on Jan. 19, 1948, presented a paper on "The Need for Increased Water Rates" before the New York Section of the American Water Works Association in which he used the ENR Construction Cost Index to demonstrate that where $1.50 per capita was expended for improvements each year before the war $2.75 to $3.00 per capita would have to be expended to get the same improvements in water supply facilities in 1948.

- **For assessment and taxes**—The ENR Construction Cost Index is a useful guide to adjust property valuations. For example, an assessment engineer, Department of Assessment and Taxation, Schenectady, New York, asks for two additional copies of the Construction and Building Cost Indexes, stating "This office is particularly interested in reproduction cost data for 1941 for residential, commercial and heavy industrial construction."

And the following comes from the chief engineer, Valuation Division, Tax Commission, State of Washington, Olympia:

"In connection with trending costs incident to the valuation of industrial and public utility property for ad valorem tax purposes, the Tax Commission of the State of Washington has use for the information and cost indexes published in your annual construction cost issue."

An assessor, Board of Assessors, Department of Revenue and Finance, City of Trenton, N. J., writes:

"We do our own appraisal work, but of course the gathering of cost data for various types of construction is a bit difficult in a town the size of Trenton; consequently, we look to other sources for complete and up-to-date data. One thing which your company has furnished in past years has been an annual cost index, by the Engineering News-Record. That is one thing that I should definitely like to have."

The use of the ENR and other construction cost index numbers for appraisal work was discussed at length in the "Harvard Business Review," Oct. 1934, Vol XIII, p. 108, by Henry W. Sweeney in a paper, "Approximation of Appraisal Values by Index Numbers." It is a discussion worth reading by all interested in this use of index numbers, with these conclusions:

"The index-number method of approximating appraisal values is inexpensive, rapid and simple. It usually cannot, of course, attain the same high degree of authoritative accuracy as can the appraisal procedure of a concern that specializes in such work. And not all the price indexes on which a wide use of the index-number method should depend are available to the business public, for the time being, at least. Appraisal values by index numbers are limited by the circumstances and purposes for which they are to be used. The accounting and financial world does not accept the viewpoint that appraisal values are better for balance-sheet purposes than are original-cost figures. Furthermore, a good deal of havoc has been wrought by using an index number for valuation purposes which, although accurate enough in itself, was not applicable to the industry or company under consideration."

• **For timing the start of work**—Both engineers and contractors are frequently consulted by their clients as to the best time to start construction jobs.

Carneal and Johnston, for example, architects-engineers in Richmond, Va., issue bulletins from time to

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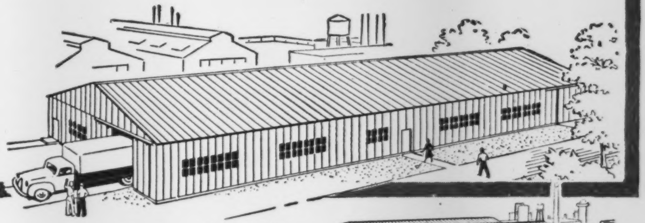
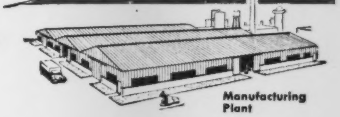
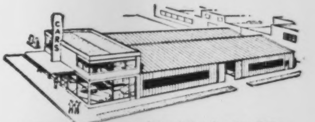


Storage Building

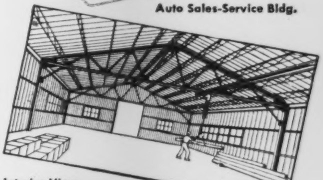


Manufacturing Plant

Truck Loading Depot



Auto Sales-Service Bldg.



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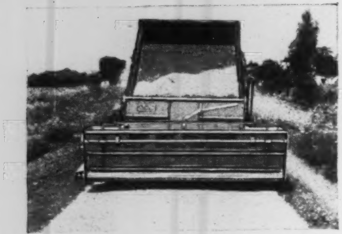

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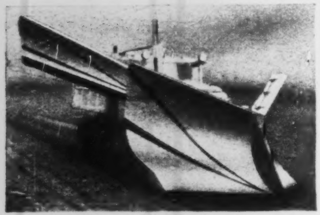

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time to advise their clients on building conditions. Their bulletin of February 1, 1949, cited the Engineering News-Record cost indexes to illustrate that "November, 1948, through January, 1949, shows the first significant break in an upward march of costs in ten years."

Reporting back on their predictions in an earlier bulletin this firm states:

"In 1945, when nearly everyone prophesied impending reductions in costs, Carneal and Johnston interviewed many sources of information in Virginia and North Carolina together with local economists, compared their findings with the Engineering News-Record's charts, and at that time issued a bulletin on which this Curve No. 4 was plotted in August, 1945, projecting very closely the developments as shown by Curve No. 1." (Curve No. 4 shows Carneal and Johnston's 1945 estimate of where the ENR curve of costs would probably go. Curve No. 1 showed where the ENR cost curve actually did go.)

Should municipalities go ahead with construction or postpone it? To answer these questions Alex Van Praag, Jr., member, and Benjamin C. Seal, engineer, Warren & Van Praag Inc., consultants, prepared a paper, "Price Trends in Municipal Construction," to be presented to a meeting of public officials. In it they state: "Chart No. 1 shows the trend of construction costs since 1903. This curve is Engineering News-Record's cost index of construction costs in which the 1913 index value equals 100. There is the Fruin-Colnon curve made up by the Fruin-Colnon Construction Company of St. Louis. We have the Turner Construction Company index, the Associated General Contractor's index, the American Appraisal Company index and many others. These indexes agree relatively closely. In this paper we prefer to talk in terms of the ENR cost index because the data and figures for the construction of the index are readily available and, in our experience, they are probably the most reliable index of such costs obtainable."

• **For operating escalator clauses—** Contractors bidding on new construction in periods of rapidly rising prices must protect themselves with a large factor of safety or allowance for contingencies. This makes contractor's bids rise faster than construction costs themselves (as measured by materials prices and labor rates) are going up.

To insure the contractor against future cost increases in materials prices and wage rates, James M. Montgomery, consulting engineer, San Francisco, Calif., in December,

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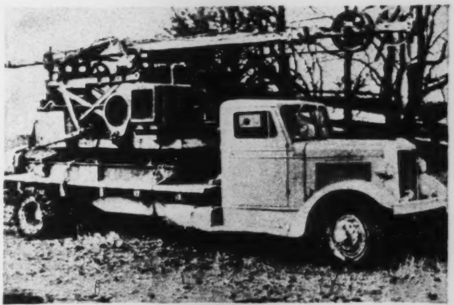

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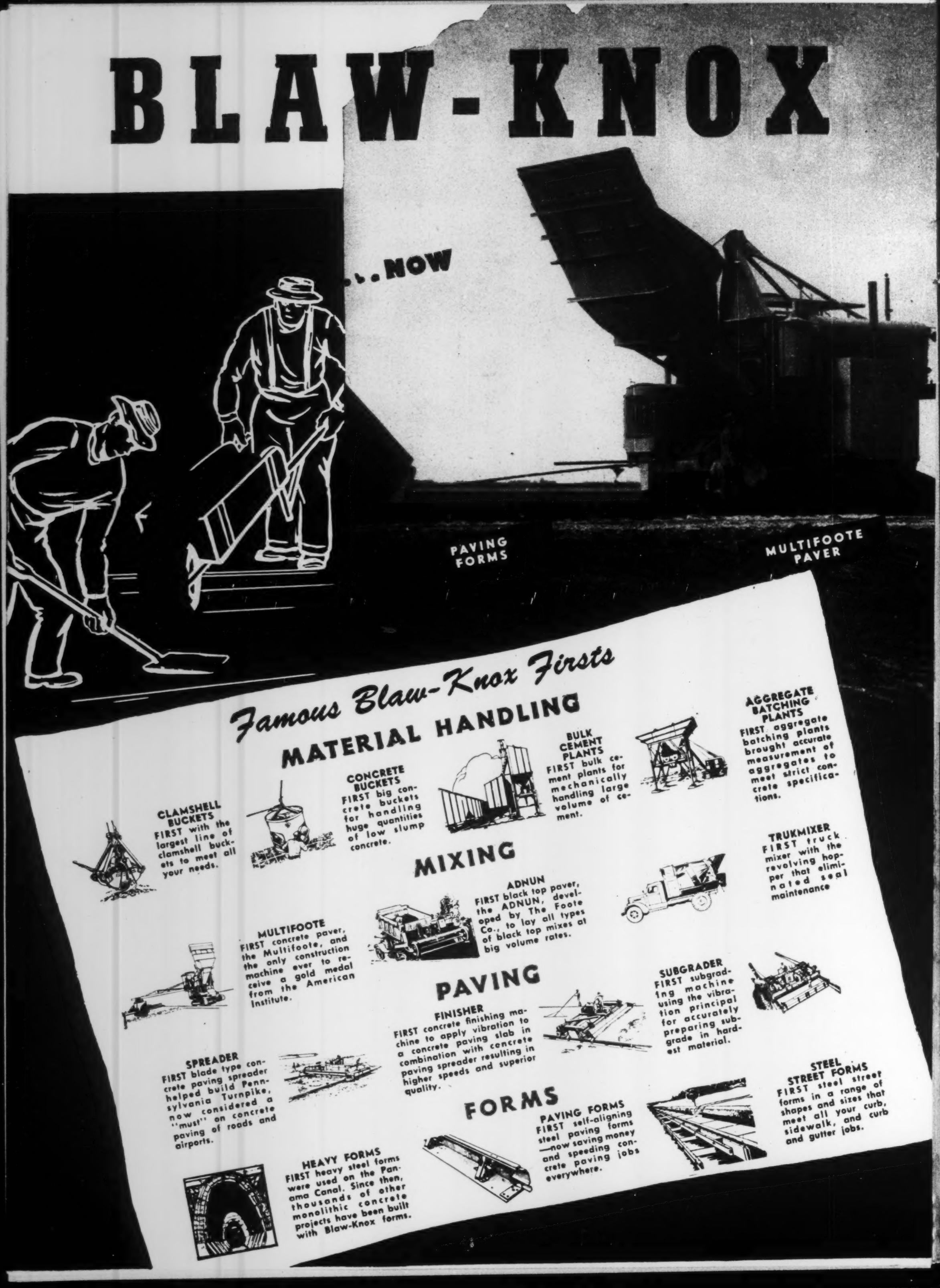

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FIRST black top paver, the ADNUN, developed by The Foote Co., to lay all types of black top mixes at big volume rates.

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FIRST concrete paver, the Multifoote, and the only construction machine ever to receive a gold medal from the American Institute.

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FIRST subgrading machine using the vibration principal for accurately preparing subgrade in hardest material.

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FIRST concrete finishing machine to apply vibration to a concrete paving slab in combination with concrete paving spreader resulting in higher speeds and superior quality.

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FIRST blade type concrete paving spreader helped build Pennsylvania Turnpike, now considered a "must" on concrete paving of roads and airports.

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STEEL STREET FORMS
FIRST steel street forms in a range of shapes and sizes that meet all your curb, sidewalk, and curb and gutter jobs.

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FIRST heavy steel forms were used on the Panama Canal. Since then, thousands of other monolithic concrete projects have been built with Blaw-Knox forms.

has set the pace for 100% mechanized concrete construction since 1906 . . .

FIRST
PAVING SPREADER VIBRATOR
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SETTING the pace through the years and staying in first place definitely established the leadership of Blaw-Knox in the development of equipment that has mechanized all the operations in concrete construction. Whatever the job —building the Panama Canal, the nation's big dams, paving Main Street or making the curb in front of your home—all the facilities, skill and experience of Blaw-Knox have been devoted to doing it better, faster and at lower cost. The result is an enviable list of FIRSTS now consolidated in the Blaw-Knox Complete Package of equipment for 100% mechanization of concrete construction sold and serviced by a nation-wide distributor organization.

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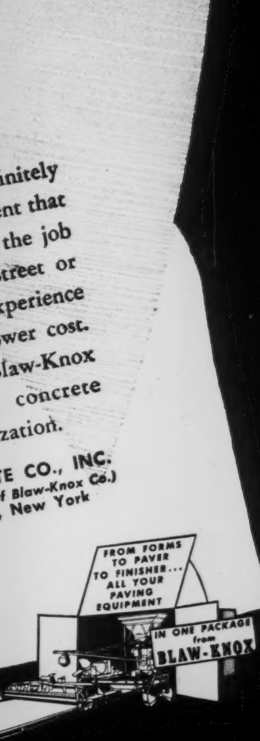
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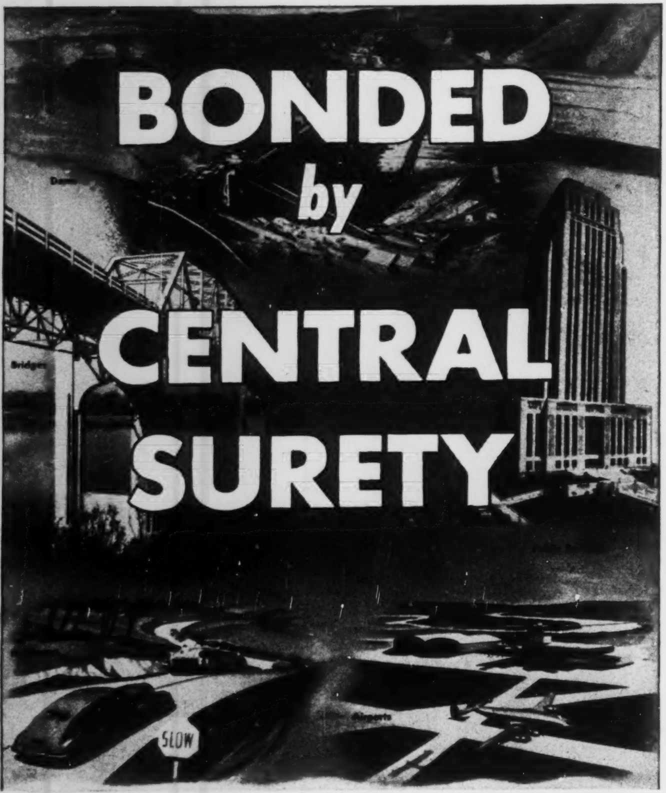

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1946, devised a basis of price adjustment tied to the ENR Construction Cost Index. The first known use of such an escalator clause was on the contract for construction of a water plant for the city of El Centro, Calif. The following paragraphs are taken from Mr. Montgomery's job specifications:

21. (c) *Computation of Price Adjustment*—The Amount earned by the Contractor during the month of the progress estimate shall be computed in accordance with Section (23) of the Specifications entitled "Progress estimates" with exceptions hereinafter provided. The amount earned by the Contractor shall be adjusted as follows:

Amount earned during the month of the progress estimate multiplied by the monthly Engineering News-Record Construction Cost Index published during the month in which the work was performed divided by the monthly Engineering News-Record Construction Cost Index published during the month in which bids were received, *provided* that if the amount so computed should exceed the amount of the monthly earnings by more than 20% the price adjustment allowed will be limited to 20% of the monthly earnings.

(d) *Exceptions*—(1) the price adjustment as computed in accordance with Subsection (c) above shall not apply to extra work or extra material furnished by the Contractor and paid for in accordance with Subsection (20b) and (20d) hereof.

(2) Where the Engineering News-Record Construction Cost Index, published during the month in which the work was performed, is equal to or less than the monthly Engineering News-Record Construction Cost Index published during the month in which bids were taken, no adjustments will be made in the amount earned by the Contractor during such month or months.

(3) No adjustment will be made in the amount earned by the Contractor after the date specified in the Contract for completion of the work. Extension in time which may be granted under terms of the Contract shall not change the above provision.

In 1948 M. S. Davis, director of public service, City of Akron, Ohio, used an escalation clause, also on waterworks contracts, that provided for adjustment down as well as up. It provided that:

"The total amount payable by the City to the Contractor under the regularly scheduled items of the Contract, as computed in the Final Estimate on the basis of the prices named by the Contractor in his proposal, shall be increased or decreased in the proportion that the direct unweighted average of the ENGINEERING NEWS-RECORD Building Cost Index as published monthly by the ENGINEERING NEWS-RECORD during the period of major construction operations under this Contract is greater or less than that Index as published during the calendar month in which the Contractor made his Proposal; provided that the amount of such increase or decrease shall not be more than twenty (20) percent of the amount of such final estimate as based on the bid prices.

"For the purpose of such price adjustment, the 'period of major construction operations' shall be defined as that period, in calendar months, during which the total value of work performed to date by the Contractor, as evidenced by the Engineer's monthly estimates, shall have increased from ten (10) or more percent to not less than ninety (90) percent of the total amount of the Contract as computed on the basis of the bid prices."

A different application of the same principle was used when work was shut down on Center Hill Dam, because of the war. The contractors, Metcalfe & Hamilton Construction Co., and the U. S. Engineers agreed that, when work was resumed after the war, unit prices originally bid would be adjusted automatically according to the difference in the ENR Construction Cost Index between the time of placing the bid and the time of resuming work on the job.

- **For zoning restrictions**—Several inquiries have come in to Engineering News-Record about the possibilities of providing for automatic adjustment of minimum requirements for restricted residential developments when costs go up. For example, if the minimum house of $20,000 is specified for a restricted area should not some provision be made to raise this to $40,000 if construction costs double? Could such a provision be based on a readily available, independent cost index, like the ENR Building Cost Index. There seems to be no reason why such an arrangement could not be worked out.
- **For fire insurance coverage**—To keep fire insurance in force, coverage must be carried on 80 percent of the value for some types of property, 90 percent of the value of others. When construction costs go up, insurable values on all types of structures go up, too.

Cost indexes may be used in two ways to meet this problem. One is to notify the insured of increased costs. Insurance companies send out notices of cost rises and caution those insured to take out coverage on the increased value. For example: An industrial

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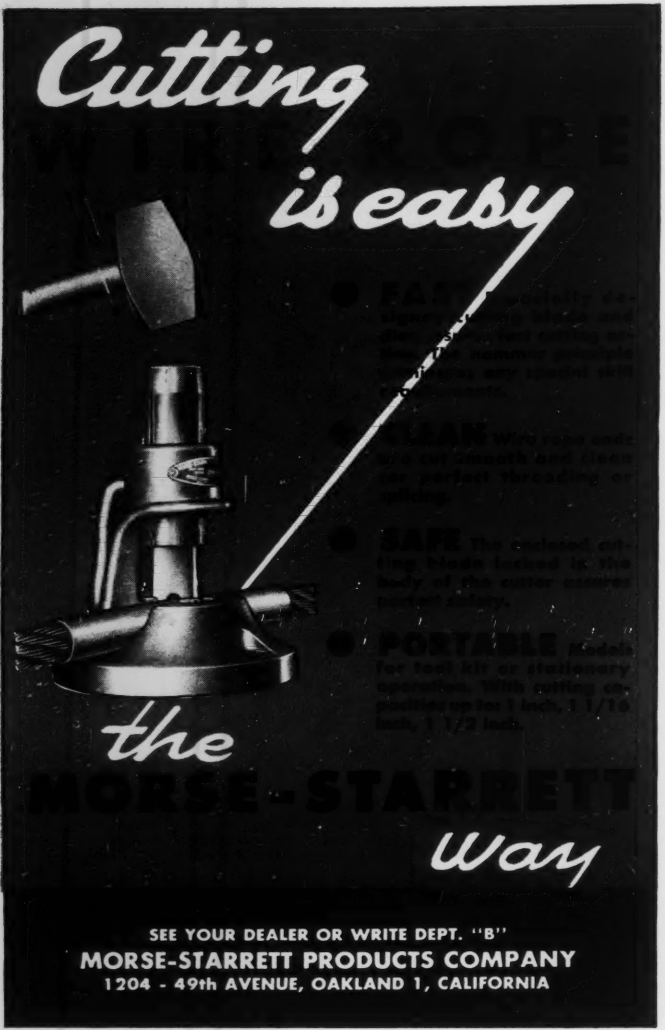

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- **PORTABLE** Models for tool kit or stationary operation. With cutting capacities up to: 1 inch, 1 1/16 inch, 1 1/2 inch.

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company in Illinois writes: "We have had submitted to us by our insurance people a copy of an Engineering News-Record Index for the period beginning in 1926 to the early part of 1947, showing increase in replacement costs of buildings." And a real estate management company in Ohio asks: "We are writing to inquire whether you publish any charts or graphs or tables showing building construction costs over past years (say back to 1913 or earlier and up to the present time). What we are interested in are figures for use in adjusting insurable values on our various store buildings."

Cost indexes may also be used to provide automatic fire insurance coverage. An engineer, representing a large company with property all over the country investigated the practicability of keeping its fire insurance coverage adjusted automatically by paying the fire insurance premiums monthly, adjusted up or down according to charges in the ENR Building Cost Index.

• **For cost comparisons**—When the New York City Housing Authority made detailed cost comparisons among public, private, and limited dividend housing, it was faced with the fact that all the buildings had been built at different times and on differing cost levels. The first job was to adjust all costs to a common base. The ENR Building Cost Index and five others were averaged to establish an index for adjusting costs to 1940 conditions.

Of the individual indexes used, the Engineering News-Record Building Cost Index ran consistently closest to the average of all six indexes, holding this median position during 9 of the 18 years studied. Aberthaw was closest for 2 years. Fruin-Colnon, 2 years; Fuller, 2 years and Turner, 3 years. The ENR Building Cost Index varied from the average a maximum of 6 percent below in 1932 to 5 percent above in 1939 and 1940. It varied from the average 2 percent or less, plus or minus, during 12 of the 18 years studied.

• **For public hearings**—On December 21, 1948, testimony was presented before the Sub-Committee on Profits of the Joint Committee of Congress on the Economic Report by Enders M. Voorhees, Chairman of the Finance Committee, United States Steel Corp. to justify a depreciation charge on the company's income statement. In pointing out that it was "unrealistic to assume that present day dollars are the same kind of dollars originally expended for existing facilities," Mr. Voorhees said, "Since then (1933) the buying power of the dollar has fallen about half way to zero. This has been reflected in rising construction costs as well as in all other costs. The construction cost index published by Engineering News-Record shows that construction costs by the fourth quarter of 1947 had increased 77 percent over 1940 and most recently the increase is nearly 100 percent. U. S. Steel has been confronted continuously with the necessity of revising upwards the amounts necessary to complete projects presently under way. On projects begun since V-J Day such increases over amounts originally authorized total some $146 million."

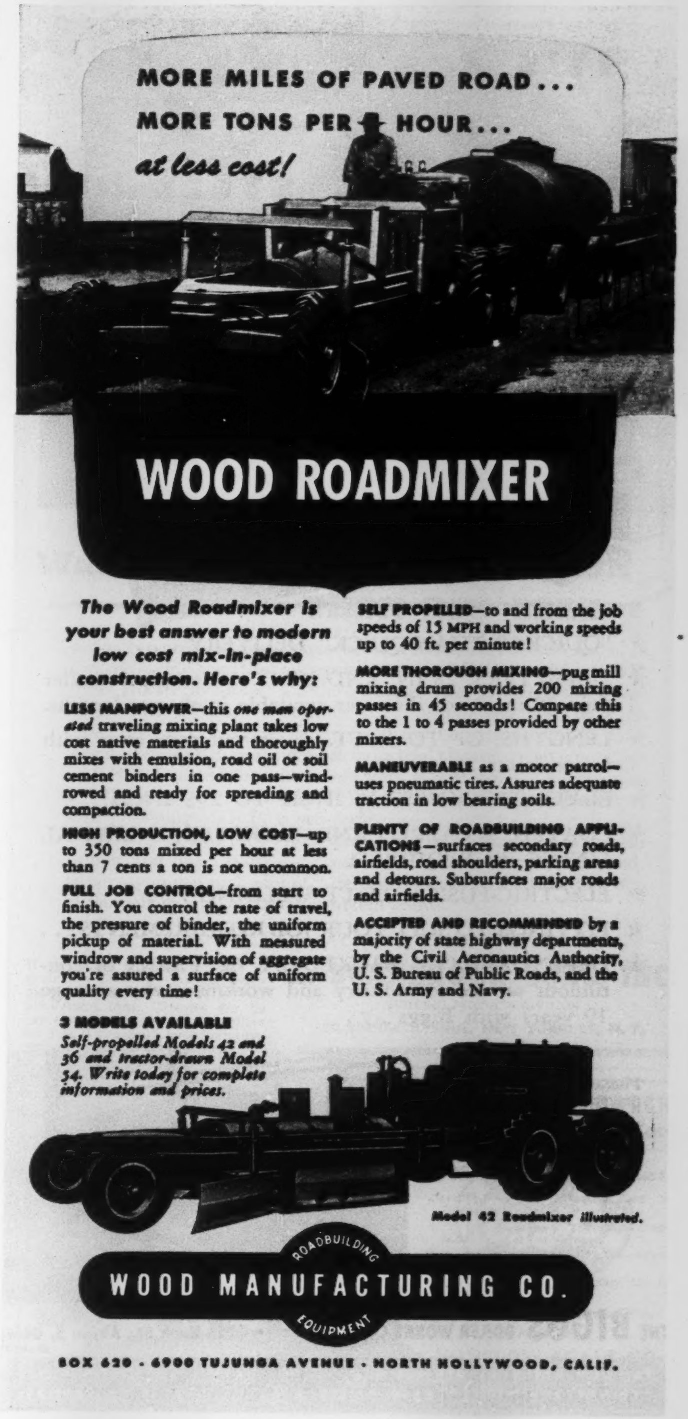
Another example is supplied by a taxpayers' fight to prevent a canal from being built. The newspaper account of this hearing reports:

"That item of $35,500,000 as the cost of building the canal, it developed at last month's hearing, is nine years old. . . . So the Western Pennsylvania crowd brought in their own engineers, headed by R. P. Forsberg, of Pittsburgh, consulting engineer.

"Engineer Forsberg pointed out—and it couldn't be regarded as a surprise to anyone—that everything, including canals, cost much more in 1944 than they did in 1935. The ENGINEERING NEWS-RECORD, trade publication of the engineering profession and generally regarded as authoritative, publishes a construction cost index accepted as accurate by the profession.

"According to this index, construction costs went up 31.9 percent from 1935 to 1941. Adding the 31.9 percent to the Engineers' 1935 costs and the Pennsylvanians got $53,067,000 as the 1941 cost to the Federal taxpayer and $5,491,000 as the cost to Beaver and Lawrence county municipalities."

- **For estimating flood damage**—An engineer in Montana writes that he has been employing the ENR Building Cost Index with a price index for food, clothing and house furnishings in computing a weighted price index for use studying flood damage to residential and other types of property as well as to highways and railroads. "I have your indexes for the years 1910 to 1948 inclusive," he writes, "and I would like to obtain them for as many years as possible prior to 1910. I plan to use this data in a study to show the effects of changing price levels in determining flood control benefits."
- **For depreciation accounting**—The rapid and large rise in construction costs following World War II has touched off lively disagreements over what property value should be used for depreciation accounting. When original cost is so far below reproduction cost, depreciation reserves fail to provide adequate replacement funds. Also taxes must be paid on higher



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LESS MANPOWER—this *one man operated* traveling mixing plant takes low cost native materials and thoroughly mixes with emulsion, road oil or soil cement binders in one pass—windrowed and ready for spreading and compaction.

HIGH PRODUCTION, LOW COST—up to 350 tons mixed per hour at less than 7 cents a ton is not uncommon.

FULL JOB CONTROL—from start to finish. You control the rate of travel, the pressure of binder, the uniform pickup of material. With measured windrow and supervision of aggregate you're assured a surface of uniform quality every time!

SELF PROPELLED—to and from the job speeds of 15 MPH and working speeds up to 40 ft. per minute!

MORE THOROUGH MIXING—pug mill mixing drum provides 200 mixing passes in 45 seconds! Compare this to the 1 to 4 passes provided by other mixers.

MANEUVERABLE as a motor patrol—uses pneumatic tires. Assures adequate traction in low bearing soils.

PLENTY OF ROADBUILDING APPLICATIONS—surfaces secondary roads, airfields, road shoulders, parking areas and detours. Subsurfaces major roads and airfields.

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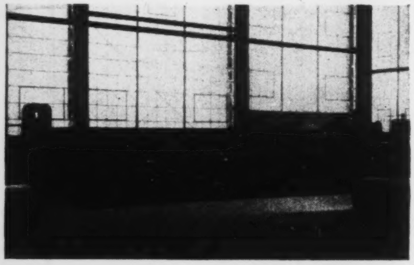

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profits where depreciation is based on low original cost, than if depreciation were based on current value.

Can accountants use ENR Construction and Building Cost Indexes, or special building cost indexes for estimating current replacement value based on original cost? The pros and cons are discussed in "An Inquiry Into the Reliability of Index Numbers," published in the Journal of Accounting, April, 1949, p. 312. This gives the results of a study by the Research Department, American Institute of Accountants. Indexes were used to derive reproduction new, depreciation, current "value." Two schools of thought developed as to whether to convert a historical cost base to an estimated current replacement cost (in which case construction cost index could be used) or whether to resolve on the "general purchasing power equivalent," (in which general price levels should be used, not special construction price levels).

This study doubted that it was worth the time, expense and effort to construct one's own index. It listed the merits of regularly published indexes as less costly, as taking less time and trouble to apply and as producing equally practical results if the published indexes are adhered to.

• **Miscellaneous uses**—The American Bankers Association, New York, writes, as follows:

"This office is preparing a weekly sheet on current trends in banking and business. The purpose of this report is to furnish to members of our own staff, as well as to selected bank executives who serve as officers or members of Association committees and commissions, a summary of highlights on current economic data. We plan to present in this report a number of weekly and monthly business and banking indicators, and would like to include current data on your Index of Building Costs."

The Bowery Savings Bank, New York, has issued a 23-page booklet analyzing construction costs as measured by four construction cost indexes (Engineering News-Record, American Appraisal, Dow, Associated General Contractors) for the use of "economists, and other well informed persons in the field of building construction regarding the outlook for building costs."

Investment bankers, Kidder, Peabody & Co., used the ENR Construction Cost Index in one of their advertisements to demonstrate that, while other construction costs were going up, the cost of their product, interest rates on new capital for financing construction, was down.

Engineering schools use the ENR

indexes in several different types of courses. Another example of instruction use for construction cost indexes is given by the Course Coordinator, School of Management, Golden Gate College, San Francisco, who writes:

"In planning the management conference on home building, for which announcement is enclosed, I am interested in the possibility of obtaining copies of the ENR Construction and Building Cost Index chart, which you publish, for distribution to about fifty registrants for these roundtable discussions."

The construction industry as a whole was accused of excessively high prices as costs rose following the war. To defend its industry against these charges of too high construction costs, the Associated General Contractors compared both its own construction cost index and the ENR Construction cost index with the BLS All commodities price index. All commodities prices were much higher than construction prices.

The foregoing examples represent some, not all, of the uses that are made of construction cost indexes. They are enough to establish the fundamental principles of index use. They are enough to illustrate the value of available, up-to-date, readily understood, properly applied indexes.

The Engineering News-Record cost index figures constitute a long series. The ENR Construction Cost Index has been computed monthly since 1914, and by years previous to that, back to 1903. The monthly values of the ENR Building Cost Index begin in 1922, and annual values have been computed back to 1910. So that readers will have the complete series available, the values are given in the following table, which continues for the next six pages.

ENGINEERING NEWS-RECORD

Cost Indexes (1903 to 1949)

Year	Construction Cost Base = 100 1913	Construction Cost Base = 100 1926	Building Cost Base = 100 1913	Building Cost Base = 100 1926
1903	93.90	45	——	——
1904	87.40	42	——	——
1905	90.55	44	——	——
1906	95.10	46	——	——
1907	100.55	51	——	——
1908	97.20	47	——	——
1909	90.92	44	——	——
1910	96.33	46	96.4	52
1911	93.43	45	94.1	51
1912	90.70	44	91.4	49
1913	100.00	48	100.00	54
1914	88.56	43	91.9	50
J	89.22	43	——	——
F	89.22	43	——	——
M	89.97	43	——	——
A	87.97	42	——	——
M	88.62	43	——	——

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Actually more resistance to weather and chemicals than red lead . . . a *tighter clinging* bond that even penetrates rust! Yet Sonneborn S.R.P. (Sure Rust Prevention) is a third *cheaper* than good red lead paint!

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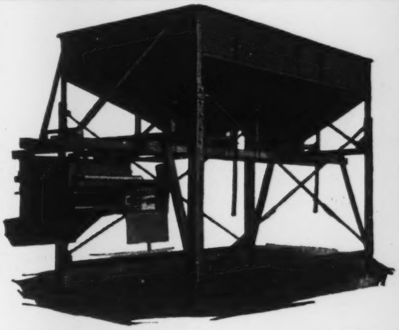

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(Continued from p. 421)

	Construction Cost Base = 100		Building Cost Base = 100	
Year	1913	1926	1913	1926
J	87.87	42	——	——
J	88.12	42	——	——
A	90.11	43	——	——
S	90.36	43	——	——
O	88.51	43	——	——
N	87.26	42	——	——
D	86.51	41	——	——
1915	92.58	45	95.3	52
J	87.12	42	——	——
F	87.36	42	——	——
M	87.66	42	——	——
A	90.16	43	——	——
M	90.16	43	——	——
J	88.96	43	——	——
J	90.51	44	——	——
A	91.76	44	——	——
S	93.01	45	——	——
O	96.16	46	——	——
N	101.06	48	——	——
D	107.06	51	——	——
1916	129.58	62	130.9	71
J	112.66	54	——	——
F	116.66	56	——	——
M	125.16	60	——	——
A	129.51	62	——	——
M	131.06	63	——	——
J	128.71	62	——	——
J	127.96	62	——	——
A	128.76	62	——	——
S	131.76	63	——	——
O	135.11	65	——	——
N	138.16	66	——	——
D	149.41	72	——	——
1917	181.24	87	166.8	90
J	167.75	81	——	——
F	167.75	81	——	——
M	175.66	84	——	——
A	183.41	88	——	——
M	187.61	90	——	——
J	199.26	96	——	——
J	204.01	98	——	——
A	198.41	95	——	——
S	190.31	92	——	——
O	167.11	80	——	——
N	166.51	80	——	——
D	167.11	80	——	——
1918	189.20	91	159.10	86
J	184.51	89	——	——
F	184.51	89	——	——
M	184.51	89	——	——
A	186.01	90	——	——
M	186.01	90	——	——
J	186.31	90	——	——
J	188.65	91	——	——
A	193.85	93	——	——
S	193.85	93	——	——
O	193.85	93	——	——
N	193.55	93	——	——
D	194.75	94	——	——
1919	198.42	95	158.77	86
J	198.05	95	——	——
F	201.50	97	——	——
M	198.05	95	——	——
A	191.25	92	——	——
M	191.25	92	——	——
J	191.25	92	——	——
J	193.65	93	——	——
A	196.65	95	——	——
S	202.85	98	——	——
O	202.25	97	——	——
N	206.85	99	——	——
D	206.85	99	——	——
1920	251.28	121	207.23	112
J	206.55	99	——	——
F	225.10	108	——	——
M	240.85	116	——	——
A	265.20	127	——	——

(Turn to p. 424)

IT'S P&H FOR ADDED VALUES!

DIG REAL DIVIDENDS!

WELLMAN

Williams Type

Welded Buckets

Operators prefer the Wellman Bucket for its balance, easy handling, and digging power. Owners prefer the Wellman Bucket for its bigger payloads, lower maintenance cost. These features are not accidental. Wellman pioneered in welded construction of rolled steels which make these buckets lighter, stronger, for greater yardage at lower costs. In all types and sizes, you'll do better with a Wellman!

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This standard, year-round reference supplies basic information on such subjects as . . .

wage rates and trends
labor productivity
labor supply
materials prices
materials shipments
contract awards
backlogs
equipment shipments
depreciation schedules
unit prices
compensation insurance
equipment rentals, etc.

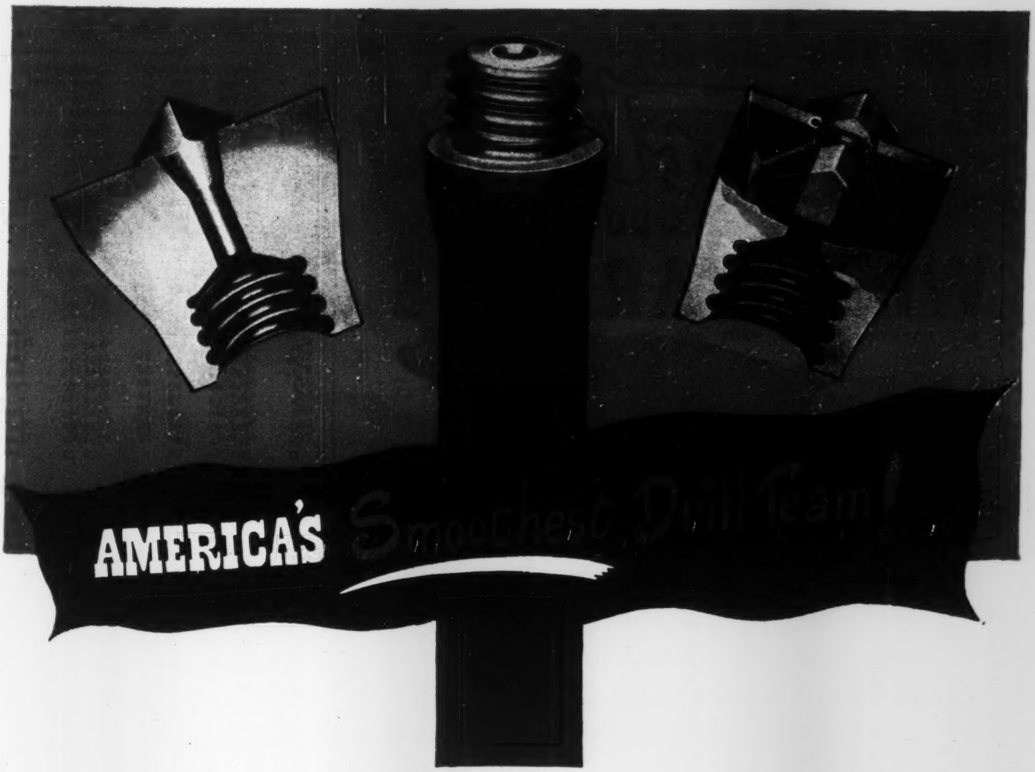
PLUS

an authoritative review of construction accomplishments in '49 and forecast of things to come in 1950.

(Continued from p. 422)

Year	Construction Cost Base = 100 1913	Construction Cost Base = 100 1926	Building Cost Base = 100 1913	Building Cost Base = 100 1926
M	268.90	129	—	—
J	273.80	132	—	—
J	265.65	128	—	—
A	252.00	121	—	—
S	255.20	123	—	—
O	255.20	123	—	—
N	255.32	123	—	—
D	251.62	121	—	—
1921	201.82	97	166.05	90
J	230.87	110	—	—
F	230.67	111	—	—
M	224.27	108	—	—
A	213.07	102	—	—
M	210.82	101	—	—
J	209.82	101	—	—
J	203.82	98	—	—
A	193.47	93	—	—
S	188.27	91	—	—
O	182.57	88	—	—
N	166.32	80	—	—
D	167.82	81	—	—
1922	174.45	84	154.85	83
J	168.72	81	147.12	80
F	168.72	81	146.47	79
M	162.04	78	145.19	78
A	164.72	79	147.12	80
M	164.62	79	149.02	81
J	166.62	80	149.77	81
J	169.70	81	150.85	82
A	173.40	83	154.55	84
S	185.00	89	164.15	89
O	188.60	91	167.75	91
N	188.60	91	167.08	90
D	192.60	97	169.10	91
1923	214.12	103	185.98	101
J	191.70	92	168.20	91
F	197.40	95	172.55	93
M	205.25	99	178.40	96
A	213.50	103	186.00	101
M	216.70	104	188.90	102
J	220.70	106	191.30	103
J	222.10	107	191.40	103
A	221.50	107	191.50	104
S	221.50	107	192.20	104
O	220.30	106	191.00	103
N	220.90	106	192.35	104
D	217.90	105	188.00	102
1924	215.36	104	185.78	101
J	217.90	105	189.30	102
F	220.30	106	191.70	104
M	224.70	180	194.10	105
A	221.60	107	191.80	104
M	222.38	107	192.48	104
J	216.85	104	187.65	101
J	214.40	103	184.50	100
A	213.15	102	183.25	99
S	211.25	102	181.35	98
O	207.55	100	178.35	96
N	205.70	99	176.50	95
D	208.58	100	178.38	96
1925	206.68	99	182.67	99
J	210.40	101	182.70	99
F	209.70	101	184.50	100
M	210.20	101	184.50	100
A	209.55	101	184.65	100
M	207.20	100	182.80	99
J	204.60	98	183.00	99
J	204.60	98	180.20	97
A	204.60	98	183.00	99
S	202.10	97	180.50	98
O	205.35	99	181.75	98
N	205.95	99	182.35	99
D	205.95	99	183.05	99
1926	208.03	100	184.99	100
J	207.15	100	184.25	100
F	206.55	99	183.65	99
M	207.65	100	184.25	100
A	207.05	100	184.05	99

(Turn to p. 426)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Look for this Mark of STERLING Quality

Sterling S WHEELBARROWS

(Continued from p. 424)

Year	Construction Cost Base = 100 1913	Construction Cost Base = 100 1926	Building Cost Base = 100 1913	Building Cost Base = 100 1926
M	207.30	100	183.55	99
J	204.80	99	181.80	98
J	207.80	100	184.30	100
A	208.30	100	185.10	100
S	208.30	100	185.10	100
O	209.80	101	187.95	102
N	210.80	101	187.95	102
D	210.80	101	187.95	102
1927	206.24	99	186.09	101
J	211.50	102	187.80	102
F	210.15	101	189.15	102
M	208.80	100	187.30	101
A	209.00	100	186.00	101
M	206.80	99	185.40	100
J	205.55	99	185.75	100
J	203.68	98	183.88	99
A	205.50	99	186.50	101
S	203.60	98	184.60	100
O	204.40	98	186.60	101
N	201.98	97	184.98	100
D	203.90	98	185.10	100
1928	206.78	99	187.97	102
J	203.90	98	185.90	100
F	204.65	98	187.15	101
M	204.65	98	187.15	101
A	206.40	99	188.80	102
M	207.00	100	190.10	103
J	206.15	99	187.55	101
J	206.65	99	187.55	101
A	207.29	100	187.55	101
S	207.29	100	187.55	101
O	207.71	100	187.55	101
N	209.46	101	188.80	102
D	210.16	101	190.00	103
1929	207.02	100	190.86	103
J	209.40	101	190.00	103
F	210.40	101	190.00	103
M	207.78	100	190.00	103
A	203.40	98	190.00	103
M	205.15	99	191.25	103
J	205.65	99	191.95	104
J	204.77	98	191.95	104
A	205.91	99	192.75	104
S	207.57	100	191.55	104
O	206.32	99	190.30	103
N	208.46	100	190.30	103
D	209.46	101	190.30	103
1930	202.85	98	185.40	100
J	208.96	100	190.30	103
F	206.46	99	188.50	102
M	206.80	100	189.20	102
A	207.12	100	188.80	102
M	205.86	99	187.90	102
J	203.36	98	185.40	100
J	200.95	97	183.25	99
A	200.95	97	183.65	99
S	199.58	96	182.40	99
O	198.72	96	181.80	98
N	198.54	95	181.80	98
D	196.86	95	181.80	98
1931	181.35	87	169.43	91
J	194.48	94	180.70	98
F	196.61	95	181.95	98
M	194.51	94	180.19	97
A	191.63	92	175.55	95
M	189.33	91	174.55	94
J	187.23	90	172.45	93
J	174.37	84	170.45	92
A	171.38	82	163.10	88
S	171.40	82	159.50	86
O	169.78	82	159.50	86
N	169.28	81	158.30	86
D	166.23	80	154.95	84
1932	156.97	75	140.94	76
J	162.48	78	150.60	81

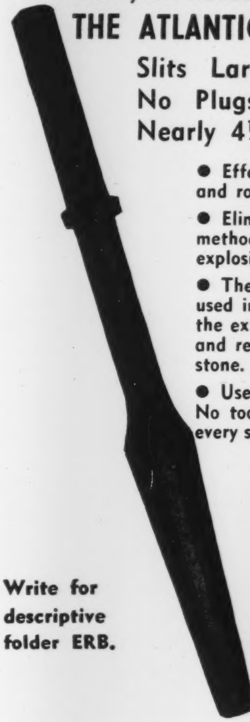
Year	Construction Cost Base = 100 1913	Construction Cost Base = 100 1926	Building Cost Base = 100 1913	Building Cost Base = 100 1926
F	161.82	78	147.20	80
M	157.24	76	145.88	79
A	153.12	74	135.68	73
M	152.78	73	136.38	74
J	152.20	73	137.58	74
J	153.36	74	139.48	75
A	156.80	75	139.40	75
S	157.96	76	139.60	75
O	159.16	77	140.00	76
N	158.20	76	139.50	75
D	158.46	76	140.00	76
1933	170.18	82	147.78	80
J	158.44	76	140.82	76
F	159.30	77	141.70	77
M	158.44	76	140.80	76
A	160.16	77	141.50	76
M	164.39	79	143.85	78
J	163.41	79	143.20	77
J	165.50	80	144.30	78
A	167.00	80	145.90	79
S	175.48	84	154.50	84
O	187.74	90	157.05	85
N	190.14	91	159.00	86
D	192.14	92	160.70	87
1934	198.10	95	166.74	90
J	191.26	92	160.15	87
F	194.06	93	161.30	87
M	194.06	93	161.70	87
A	195.86	94	163.15	88
M	199.61	96	168.15	91
J	199.61	96	168.15	91
J	199.65	96	169.15	92
A	198.40	95	168.40	92
S	200.58	96	170.10	92
O	200.86	97	170.20	92
N	201.36	97	170.20	92
D	201.86	97	170.20	92
1935	196.44	94	165.76	90
J	198.22	95	166.50	90
F	197.07	94	165.75	90
M	194.41	94	164.10	89
A	194.65	94	164.40	89
M	193.96	93	163.30	88
J	196.73	95	164.85	89
J	197.43	95	165.25	89
A	197.45	95	166.20	90
S	197.30	95	166.05	90
O	197.50	95	167.30	91
N	197.35	95	167.30	91
D	197.20	95	167.15	90
1936	206.42	99	172.18	93
J	201.23	97	168.25	91
F	201.33	97	168.43	91
M	201.63	97	169.68	92
A	202.80	98	170.00	92
M	204.05	98	170.35	92
J	205.08	99	170.18	92
J	204.80	98	170.85	92
A	208.48	100	173.93	94
S	208.88	100	174.33	94
O	211.53	102	175.33	95
N	211.50	102	175.50	95
D	215.70	103	179.30	97
1937	234.71	113	196.15	106
J	221.20	106	185.45	100
F	222.05	107	186.55	101
M	224.75	108	187.65	101
A	231.35	111	194.95	105
M	233.45	112	197.15	107
J	237.25	114	199.20	108
J	239.90	115	199.80	108
A	240.65	116	200.65	109
S	241.62	116	200.62	109
O	241.90	116	201.00	109
N	241.40	116	200.30	108
D	241.05	116	200.45	109

(*Turn to p. 431*)

ATLANTIC Pneumatic TOOLS

Use with your standard power pavement equipment . . . .

THE ATLANTIC PNEUMATIC ROCK BREAKER



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No Plugs and Feathers — No Explosives
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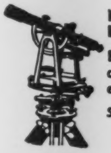

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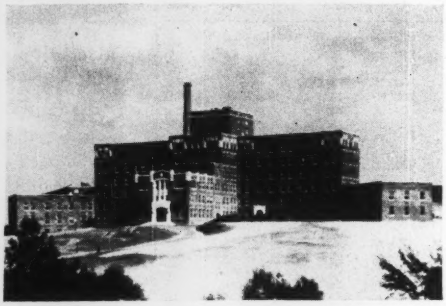

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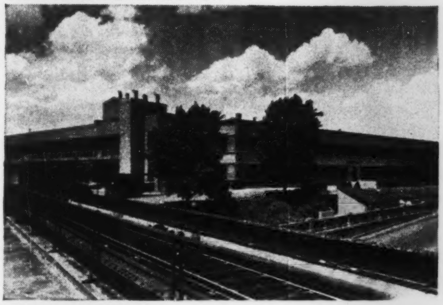

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● As proof, and as guarantee of our ability, CONSOLIDATED refers you to its long list of satisfied clients — clients convinced not only of our engineering and construction ability, but our responsibility to a trust and an earnest desire to produce results of outstanding merit.

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● CONSOLIDATED stands ready to place at your disposal its highly trained and efficient organization, equipped to construct *Anything — Any Size — Anywhere.* And, our "Know-How" insures for you procurement of materials at right prices, an integrated schedule, and a completely coordinated project resulting in satisfaction to Engineer, Architect and Owner.

● This, our past achievement, is yours. We invite your inquiries today. Brochure will be mailed on request.

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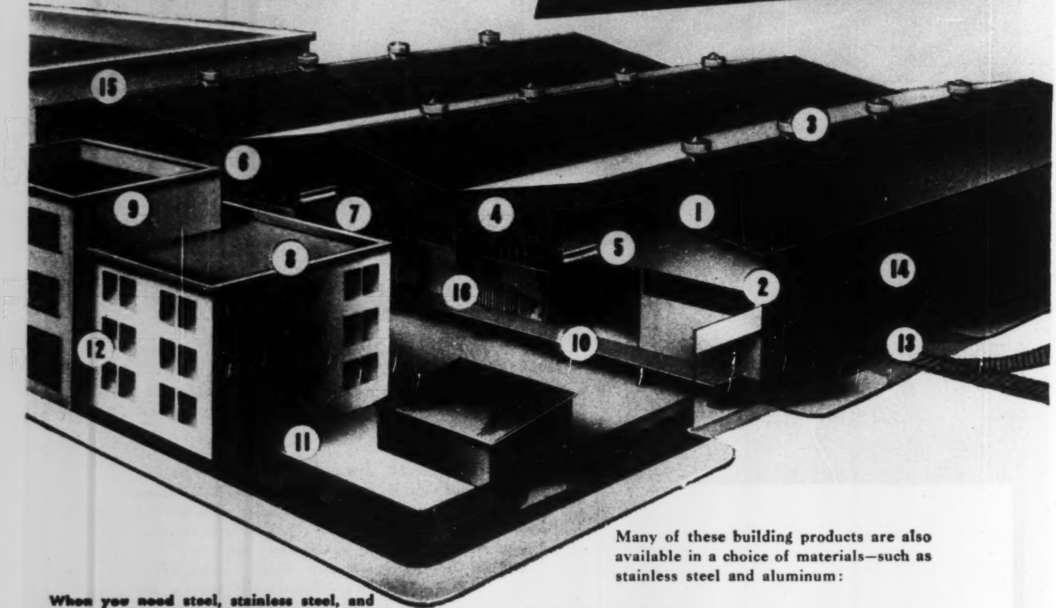

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UNITED STATES STEEL

(Continued from p. 427)

Year	Construction Cost Base = 100 1913	Construction Cost Base = 100 1926	Building Cost Base = 100 1913	Building Cost Base = 100 1926
1938	235.83	113	196.83	106
J	239.62	115	198.62	107
F	238.99	115	198.99	108
M	238.79	115	199.29	108
A	237.95	114	198.21	107
M	236.80	114	197.86	107
J	236.86	114	198.22	107
J	232.29	112	194.39	105
A	232.39	112	194.49	105
S	232.70	112	194.80	105
O	234.30	113	195.48	106
N	234.40	113	195.58	106
D	234.89	113	196.07	106
1939	235.51	113	197.44	107
J	234.72	113	196.24	106
F	234.31	113	196.23	106
M	234.43	113	196.46	106
A	234.86	113	196.45	106
M	234.69	113	196.60	106
J	235.02	113	196.41	106
J	234.94	113	196.78	106
A	234.90	113	196.54	106
S	234.97	113	196.61	106
O	236.86	114	198.50	107
N	238.20	115	201.24	109
D	238.17	114	201.21	109
1940	241.96	116	202.81	110
J	238.34	115	201.52	109
F	238.32	115	201.50	109
M	238.29	115	201.47	109
A	238.26	115	201.44	109
M	238.86	115	201.17	109
J	241.59	116	201.65	109
J	242.15	116	201.68	109
A	242.18	116	201.71	109
S	244.13	117	203.13	110
O	245.02	118	204.02	110
N	247.24	119	206.24	111
D	249.12	120	208.19	113
1941	257.84	124	211.46	114
J	249.69	120	207.94	112
F	250.50	120	208.42	113
M	250.71	121	207.88	112
A	252.40	121	208.60	113
M	255.55	123	209.24	113
J	256.79	123	209.41	113
J	258.18	124	210.22	114
A	260.41	125	212.45	115
S	263.12	126	214.58	116
O	264.46	127	215.92	117
N	266.13	128	216.54	117
D	266.16	128	216.37	117
1942	276.31	133	222.39	120
J	267.63	129	217.12	117
F	269.41	130	218.44	118
M	269.71	130	218.88	118
A	271.78	131	219.55	119
M	272.30	131	220.14	119
J	274.19	132	221.18	120
J	277.65	133	223.45	121
A	281.61	135	225.39	122
S	281.61	135	225.46	122
O	282.44	136	225.90	122
N	283.64	136	226.58	122
D	283.69	136	226.63	123
1943	289.95	139	228.75	124
J	283.45	136	226.87	123
F	283.48	136	226.90	123
M	285.24	137	226.66	123
A	288.80	139	227.50	123
M	289.87	139	227.64	123
J	289.94	139	227.71	123
J	289.92	139	227.89	123
A	291.38	140	228.49	124
S	294.09	141	231.20	125
O	294.31	141	231.29	125
N	294.41	142	231.39	125
D	294.51	142	231.49	125

(Turn to p. 432)

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(Continued from p. 431)

Year	Construction Cost Base = 100 1913	Construction Cost Base = 100 1926	Building Cost Base = 100 1913	Building Cost Base = 100 1926
1944	298.72	144	234.73	127
J	294.57	142	231.55	125
F	295.05	142	232.03	125
M	295.34	142	232.32	126
A	297.70	143	234.50	127
M	298.00	143	234.80	127
J	298.72	144	235.33	127
J	299.94	144	235.55	127
A	300.42	144	236.09	128
S	300.46	144	236.00	128
O	301.06	145	236.00	128
N	301.09	145	236.10	128
D	302.30	145	236.51	128
1945	307.75	148	239.14	129
J	302.50	145	236.51	128
F	303.70	146	237.71	129
M	304.50	146	237.85	129
A	306.43	147	238.46	129
M	307.43	148	238.46	129
J	308.99	149	239.37	129
J	308.99	149	239.64	130
A	309.08	149	239.94	130
S	309.28	149	240.07	130
O	309.28	149	240.35	130
N	309.28	149	240.55	130
D	313.48	151	240.82	130
1946	346.04	166	262.35	142
J	316.32	152	242.23	131
F	319.52	154	243.94	132
M	323.83	156	245.41	133
A	334.59	161	254.37	138
M	340.50	164	258.06	140
J	348.72	168	265.28	143
J	354.70	171	267.25	144
A	361.37	174	272.29	147
S	360.19	173	272.37	147
O	360.94	174	273.01	148
N	362.47	174	273.99	148
D	369.30	178	279.97	151
1947	413.16	199	312.96	169
J	386.97	168	294.62	159
F	393.73	189	301.56	163
M	395.45	190	303.28	164
A	399.56	192	305.21	165
M	399.98	192	304.64	165
J	406.63	195	307.42	166
J	413.75	199	308.90	167
A	422.85	203	317.75	172
S	426.38	205	322.58	174
O	434.58	209	327.29	177
N	436.91	210	329.22	178
D	441.13	212	333.06	180
1948	460.72	221	344.51	186
J	441.65	212	333.58	180
F	442.67	213	335.49	181
M	443.60	213	334.22	181
A	443.64	214	334.56	181
M	444.86	213	333.93	181
J	455.80	219	339.26	183
J	464.83	223	342.42	185
A	477.11	229	355.45	192
S	478.40	230	356.70	193
O	480.21	231	357.07	193
N	478.25	230	355.86	192
D	477.66	230	355.55	192
1949				
J	477.41	229	354.91	192
F	475.37	229	352.87	191
M	474.80	228	352.47	191
A	473.54	228	351.35	190
M	472.10	227	348.92	189
J	473.78	228	349.28	189
J	477.46	230	349.39	189
A	478.28	230	350.72	190

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NEW YORK LOS ANGELES

Bids: September 28, 1949 (336)

Preliminary Treatment Plant

DEPARTMENT OF PUBLIC WORKS,
BUREAU OF WATER

Sealed proposals will be received at Room 903, City Hall Annex, until 12 o'clock noon Eastern Standard Time, Wednesday, September 28, 1949 and opened at that time in Room 1025, City Hall Annex, for the following contract:

126-WWI—Construction of Preliminary Treatment Plant and Appurtenances at Queen Lane Filter Plant. (READVERTISEMENT)

The contract will consist of the construction of concrete basins, substructure of Chemical Building, conduits, shafts, sewers and appurtenant structures and furnishing and installing mixing and sludge collecting equipment, meters, valves, piping, sluice gates and all appurtenant work and equipment.

Plans, Specifications, Forms of Proposal and Contract and Prequalification Questionnaire may be examined or copies obtained at the Office of the Bureau of Water, Room 819, City Hall Annex, upon making a deposit of $25.00 by check, made payable to the City Treasurer of the City of Philadelphia, which will be refunded upon return of the plans and specifications in good condition within ten (10) days after the contract is awarded.

Each proposal shall be accompanied by either a certified check or certificate of deposit issued by a responsible bank or trust company, or bonds of the City of Philadelphia for the amount specified in the City Ordinance approved October 29, 1940, copy of which forms a part of the contract documents.

NOTICE: No bid for this work will be received unless the Prequalification Questionnaire of the bidder, with all questions fully answered has been filed with the Director of the Department of Public Works at least one (1) week before the date of opening bids.

Thomas Buckley, Director

U. S. Government

UNITED STATES DEPARTMENT OF THE INTERIOR, Bureau of Reclamation. Sealed bids (Specifications No. 2769) will be received by Bureau of Reclamation, Redding, California, September 27, 1949, and then publicly opened for furnishing labor and materials and performing all work for the completion of lower vista house, powerhouse adit, and elevator lobbies at Shasta Dam, Central Valley Project, California. The work is situated at Shasta Dam about 10 miles north of Redding, California. Principal items are approximately: 6,800 sq. ft., terrazzo; 730 sq. yds., plaster; 6,900 sq. ft., terra cotta and tile; and other work. Time allowed for completion will be 240 days. For particulars, address Bureau of Reclamation, Redding, California; or Building 1-A, Denver Federal Center, Denver, Colorado.

MICHAEL W. STRAUS, Commissioner.
(335)

UNITED STATES DEPARTMENT OF THE INTERIOR, Bureau of Reclamation. Sealed bids (Specifications No. 2768) will be received by Bureau of Reclamation, Tracy, California, September 29, 1949, and then publicly opened for furnishing labor and materials and performing all work for the construction of Tracy switchyard, Central Valley Project, California. The work is situated in Alameda County approximately 9 miles northwest of Tracy, California. Principal items are approximately: 48,000 cu. yds. excavation, 45,000 cu. yds. backfill, 5,600 cu. yds. concrete, constructing concrete control building complete, installing 3,000,000 lbs. electrical equipment with conduit, constructing water distribution and sewerage system; and other work. Time allowed for completion will be 560 days. For particulars, address Bureau of Reclamation, Tracy, California; or Building 1-A, Denver Federal Center, Denver, Colorado.

MICHAEL W. STRAUS, Commissioner.
(334)

ADDITIONAL PROPOSAL ADVERTISING
On Pages
435, 438, 439, 440, 441, 442, 443

Bids: September 14, 1949 (333)

State Road Work

NOTICE TO CONTRACTORS: STATE DEPARTMENT OF PUBLIC WORKS, ALBANY, N. Y.—Pursuant to the provisions of (1) the Highway Law and special provisions therein for projects financed with federal aid funds, (2) the Canal Law (3) the Public Buildings Law, sealed proposals will be received until ten-thirty o'clock A.M., advanced standard time, which is nine-thirty o'clock A.M., eastern standard time on Wednesday, September 14, 1949 by Henry A. Cohen, Director, Bureau of Contracts & Accounts, 14th Floor, The Governor Alfred E. Smith State Office Building, Albany, N. Y., for the following projects: **Maps, plans, specifications and proposal forms may be seen and obtained at the office of the State Department of** Public Works, Bureau of Contracts & Accounts, Albany, N. Y., and at the office of the District Engineers noted below, and may also be seen at the office of the State Department of Public Works, 270 Broadway, New York City.

The deposit for plans and proposal forms for each contract containing 1 to 15 sheets is $5.00; 16 to 30 sheets, $10.00; over 30 sheets, $20.00. **A refund will be made in full to bidders for the return of one set in good condition within 30 days of award or rejection of bids; refund for all other sets in good condition, similar period, will be** 50% **of deposit.**

DISTRICT No. 1

County	Contract No.	Name	Miles	Type	Deposit	Estimated Cost of Work
		G. L. NICKERSON, Dist. Engr., 353 Broadway, Albany, N. Y.				
Greene	RC49-97	Palenville-Catskill, S. H. 8231	0.54	Asph. Conc. Optional	$4,500 Plans $5	$80,000.00
Rensselaer	RC49-110	Center Berlin-Petersburg, S. H. 1421 Stephentown-Center Berlin S. H. 8163	0.18	8" Cem. Conc. Pavt. 22' Wide Reinf. Conc. Slab Br. 23½' Span	$3,500 Plans $5	$60,000.00
Warren	FARC49-96	Warrensburg-Chestertown, Pt. 1, S. H. 5157 Proj. FI-490(6)	0.97	8" Cem. Conc. Pavt. 24'-40' Wide=0.95 mi. Misc. Work=0.02 mi.	$12,000 Plans $5	$223,000.00
DISTRICT No. 2						
		L. KETCHUM, Dist. Engr., 109 No. Genesee Street, Utica, N. Y.				
Oneida	———	Eberts Bridge Over Black River Reservoir	0.06	Asph. Conc. Optional 2 Sp. I-Beam 64' 7" & 38' 3"	$1,700 Plans $5	$31,703.50
DISTRICT No. 3						
		WM. ROBINSON, Dist. Engr., Weigh Lock Bldg., Syracuse, N. Y.				
Onondaga & Madison	MT49-2	Mohawk Thruway (Thompson Rd. to Chittenango Creek)	5.91	Grad. & Struct. & F. C. 2 Alpha I-Beams 92' 4" Span Ea. 1 I-Beam 50' Span Alpha = $541.80	$120,000 Plans $20	$2,093,000.00
DISTRICT No. 5						
		C. R. WATERS, Dist. Engr., 65 Court Street, Buffalo, N. Y.				
Erie	OT49-7 SS49-26 SS49-27 SS49-28	Ontario Thruway Cleveland Drive Maryvale Drive George Urban Boulevard	1.10	9" 2 Crse. Cem. Conc. Pavt., 24', 74' Wide = 0.77 mi. Asph. Conc. Opt.=0.11 mi. Fdt. Crse. Rob Grav.= 0.10 mi. Misc. Work =0.12 mi. Alpha I-Beam 2 Spans 40', 2 Spans 60' Alpha I-Beam 2 Spans 44', 2 Spans 66' Alpha I-Beam 2 Spans, 47', 2 Spans 70' Alpha = $966.00	$55,000 Plans $10	$977,000.00
DISTRICT No. 6						
		H. F. BRUMM, Dist. Engr., 30 West Main Street, Hornell, N. Y.				
Steuben, Chemung & Schuyler	F. C. 49-3	Flood Control Project in Dist. No. 6	——	Furnish. & Erect. R. O. W. Markers	5% of Bid Plans $5	$10,451.00
DISTRICT No. 8						
		J. S. BIXBY, Dist. Engr., Pleasant Valley Road, Poughkeepsie, N. Y.				
Westchester	FARC49-100 FARC C49-101	Peekskill-Annsville Br., S. H. 1850; Peekskill-Fishkill, Pt. 1, S. H. 5147; Bear Mountain Br.: East Approach, S. H. 9297; Peekskill-Annsville Bridge Connection C47-4 Project No. F&U394(9)	1.56	9" Cem. Conc. Pavt. 24', 48' & 60' Wide= 0.78 Mi. 9" Cem. Conc. Pavt. Var. Widen = 0.02 Mi. Bit. Mac. Ty. 1, Pen. Method=0.76 Mi. 4 Sp. Deck Gird. 280' Total Rig. Frame Conc. Arch 26' 6" Span	$40,000 Plans $20	$766,000.00
Rockland	RC49-99	Knapps Corners-Nyack, S. H. 5178	——	Repairs to Br. No. 2	$100 Plans $5	$1,900.00
DISTRICT No. 9						
		F. W. DONOVAN, Dist. Engr., 71 Frederick Street, Binghamton, N. Y.				
Broome	FAC49-8	Binghamton City: Vestal Avenue Bypass (West City Line to Pennsylvania Ave.) Proj. U1019(2)	1.81	9" Cem. Conc. Pavt. 48' Wide=1.68 Mi. Asph. Conc. Opt.= 0.13 Mi.	$70,000 Plans $10	$1,214,000.00
DISTRICT No. 10						
		J. J. DARCY, Dist. Engr., Montauk Hwy. at Little E. Neck Rd., Babylon, L. I., N. Y.				
Bronx	FAGM C49-9	Elim. of Grade Xing of N. Y. C. R. R. With Melrose Ave. & E. 165th Street Proj. FAGM 922F(1) Off	0.21	Misc. Pavt.=0.08 Mi. Gr. Sep. Struct.=0.13 Mi.	$35,000 Plans $20	$616,000.00
		Total Letting	12.34	Miles		
			59	Bridges to be Painted		$6,488,354.50
			3,448,325	Sq. Yds. } Waterproofing		
			25,500	Gals. } Waterproofing		
BRIDGE PAINTING WORK						
DISTRICT No. 1						
		G. L. NICKERSON, Dist. Engr., 353 Broadway, Albany, N. Y.				
Albany, Greene, Saratoga, Rensselaer & Washington	RC49-91	Br. No. 3, S. H. 886; Br. No. 1, S. H. 8482; Br. No. 1, S. H. 8488; Br. No. 1, S. H. 5040; Br. No. 2, S. H. 490; Br. No. 1, S. H. 9311; Br. No. 1, S. H. 1938; Br. No. 4, S. H. 1685; Br. No. 1, S. H. 1835; Br. No. 1, S. H. 9016; Dunn Bridge, S. H. 9111; Troy-Menands Br., S. H. 9112; 112th St. Br.; Congress Street Br.	——	Painting Bridges	$6,000 Plans $5	$116,000.00
DISTRICT No. 2						
		L. KETCHUM, Dist. Engr., 109 No. Genesee Street, Utica, N. Y:				
Montgomery	RC49-80	Br. No. 1, Fultonville Vill.: Fonda Vill., S. H. 864; Br.	——	Painting Bridges	$1,100 Plans $5	$20. 00.0

(Continued on page 435)

OFFICIAL PROPOSALS

(Continued from page 434)

		No. 1, Fort Plain Vill.: River St., S. H. 1903; Br. No. 1, Canajoharie-Palatine Bridge, S. H. 8527-8528				
		DISTRICT No. 3 Wm. Robinson, Dist. Engr., Weigh Lock Bldg., Syracuse, N. Y.				
Seneca & Wayne	RC49-82	Seneca Falls Vill., S. H. 5100, Br. No. 1; Geneva-Waterloo, S. H. 5087A, Br. No. 1; Newark-Lyons, S. H. 8028, Br. No. 1	——	Painting Bridges	$800 Plans $5	$15,000.00
		DISTRICT No. 6 H. F. Brumm, Dist. Engr., 30 West Main Street, Hornell, N. Y.				
Allegany & Steuben	RC49-98	Br. No. 4, S. H. 5204; Br. No. 2, S. H. 0349; Br No 1 A, S. H. 5130; Br. No. 4, S. H 8253	——	Painting Bridges	$600 Plans $5	$11,000.00
Chemung & Tioga	RC49-81	Southport, Pt. 2, S. H. 28, Br. No. 1; Waverly-Owego, Pt. 3, S. H. 5257, Br. No. 10; Owego-Candor, Pt. 2, S. H. 5471, Br. No. 10	——	Painting Bridges	$500 Plans $5	$10,000.00
		DISTRICT No. 8 J. S. Bixby, Dist. Engr., Pleasant Valley Road, Poughkeepsie, N. Y.				
Orange, Rockland & Ulster	RC49-83	Br. No. 3, S. H. 42; Br. No. 5, S. H. 499; Br. No. 1, S. H. 1539; Brs. Nos. B-1 & B-2, S. H. 5480; Br. No. 2, S. H. 8300; Br. No. 1, S. H. 689; Br. No. B-2, S. H. 5388; Br. No. 1, S. H. 5714; Br. No. 1, S. H. 8049A; Brs. Nos. 1 & 2, S. H. 141; Br. No. 3, S. H. 229; Br. No. 1, S. H. 419; Br. No. 3, S. H. 1419; Br. No. 1, S. H. 5599C; Br. No. B-1, S. H. 5601; Br. No. 1, S. H. 8398	——	Painting Bridges	$4,500 Plans $5	$82,000.00
		DISTRICT No. 9 F. W. Donovan, Dist. Engr., 71 Frederick Street, Binghamton, N. Y.				
Broome, Delaware, Schoharie, Sullivan	RC49-89	Br. No. 1, S. H. 5338; Br. No. 1, S. H. 1241; Br. No. 1, S. H. 5412; Br. No. 1, S. H. 375; Br. No. 1, S. H. 8254; Br. No. 1, S. H. 5393; Br. No. 1, S. H. 5671; Br. No. 1, S. H. 8187; Br. No. 1, S. H. 5458; Br. No. 1, S. H. 5286; Br. No. 1, S. H. 5195; Br. No. 3, S. H. 5234; Br. No. 1, S. H. 8449; Br. No. 1, S. H. 8494	——	Painting Bridges	$4,000 Plans $5	$73,000.00
		WATERPROOFING PAVEMENT WORK DISTRICT No. 1 G. L. Nickerson, Dist. Engr., 353 Broadway, Albany, N. Y.				
Albany, Greene, Rensselaer, Columbia, Saratoga, Schenectady & Washington	RC49-102	Eight Contracts in District No. 1	562,532	Waterproof. Pavt.	$700 Plans $5	$13,000.00
		DISTRICT No. 2 L. Ketchum, Dist. Engr., 109 No. Genesee Street, Utica, N. Y.				
Herkimer, Madison, Montgomery, Oneida	RC49-103	Seven Contracts in District No. 2	539,000	Waterproof. Pavt.	$650 Plans $5	$12,000.00
		DISTRICT No. 3 Wm. Robinson, Dist. Engr., 301 E. Water Street, Syracuse, N. Y.				
Cayuga, Onondaga, Oswego, Wayne	RC49-104	Six Contracts in District No. 3	559,223	Waterproof. Pavt.	$700 Plans $5	$13,000.00
		DISTRICT No. 4 A. R. Mulligan, Dist. Engr., Barge Canal Term., Rochester, N. Y.				
Genesee, Monroe, Ontario	RC49-105	Nine Contracts in District No. 4	531,815	Waterproof. Pavt.	$650 Plans $5	$12,000.00
		DISTRICT No. 5 C. R. Waters, Dist. Engr., 65 Court Street, Buffalo, N. Y.				
Chautauqua Cattaraugus, Erie	RC49-106	Five Contracts in District No. 5	237,500	Waterproof. Pavt.	$300 Plans $5	$5,300.00
		DISTRICT No. 7 R. F. Hall, Dist. Engr., 444 VanDuzee Street, Watertown, N. Y.				
Lewis & Jefferson	RC49-107	Five Contracts in District No. 7	91,805	Waterproof. Pavt.	$110 Plans $5	$2,000.00
		DISTRICT No. 8 J. S. Bixby, Dist. Engr., Pleasant Valley Road, Poughkeepsie, N. Y.				
Columbia, Dutchess, Orange, Putnam, Rockland, Ulster, Westchester	RC49-108	Thirteen Contracts in District No. 8	447,400	Waterproof. Pavt.	$550 Plans $5	$10,000.00
		DISTRICT No. 9 F. W. Donovan, Dist. Engr., 71 Frederick Street, Binghamton, N. Y.				
Broome, Chenango, Delaware, Otsego, Tioga, Schoharie	RC49-109	Ten Contracts in District No. 9	479,050	Waterproof. Pavt.	$600 Plans $5	$11,000.00
		DISTRICT No. 10 J. J. Darcy, Dist. Engr., Montauk Hwy. at Little E. Neck Rd., Babylon, L. I., N. Y.				
Nassau & Suffolk	NSP49-2 SSP49-4	Northern State Pkwy. & Southern State Pky.	——	Waterproof. Pavt.	$600 Plans $5	$10,000.00

Proposal for each contract must be submitted in a separate sealed envelope with the name and number of the contract plainly endorsed on the outside of the envelope. Each proposal must be accompanied by cash, draft or certified check payable to the order of "State of New York, Commissioner of Taxation & Finance" for the sum as specified in the advertisement and the proposal. The retention and disposal of the bidding check, the execution of the contract and bonds shall conform to the provisions of the Highway Law, et al as set forth in "Instructions to Bidders".

When optional types are permitted on contracts with federal funds, bidders must state in the space provided in the proposal the exact designation of the optional type upon which the proposal is predicated.

The right is reserved to reject any or all bids.

B. D. TALLAMY
SUPT. OF PUBLIC WORKS

OFFICIAL PROPOSALS

Bids: September 6, 1949 (337)

Additional Burning Unit at Lyttonsville Incinerator

WASHINGTON SUBURBAN SANITARY COMMISSION
CONTRACT NO. 651

Sealed proposals for work under the above contract will be received at the office of the Washington Suburban Sanitary Commission, Hamilton Street, Hyattsville, Maryland until Tuesday, September 6, 1949 at 1:30 P.M., Eastern Daylight Saving Time, at which place and time they will be publicly opened and read. This work consists of furnishing and installing an additional furnace, combustion chamber, necessary flues and appurtenances; also the motorizing of the two existing charging gates, and the substitution of variable speed motors for constant speed motors on the blowers of the two existing burning units.

Plans and specifications may be obtained from the office of the Chief Engineer of the Commission, Hyattsville, Maryland, upon deposit of $10.00, which deposit will be returned to bidders or to those returning plans and specifications in good condition.

Dwight B. Galt
Warren Browning
Leland G. Worthington
Commissioners

Bids: September 15, 1949 (339)

Taxiway and Apron Paving for Hangars No. 3, No. 4 and No. 5

THE PORT OF NEW YORK AUTHORITY
NEW YORK INTERNATIONAL AIRPORT
CONTRACT NYA-24

Sealed proposals for the paving of taxiways and aprons for Hangars No. 3, No. 4 and No. 5 at New York International Airport will be received at the office of the Chief Engineer of The Port of New York Authority, Room 1100, 111 Eighth Avenue, New York 11, N. Y., until 2:00 P. M. Thursday, September 15, 1949, and thereafter in the Auditorium of the Authority at the same address until 2:30 P. M., on the same date at which latter time and place said proposals will be publicly opened and read.

Contract documents may be seen at the office of the Chief Engineer, and copies will be furnished upon deposit of $25.00 per set. The deposit will be remitted if the documents are returned in good condition, not later than thirty days after the opening of proposals.

THE PORT OF NEW YORK AUTHORITY
Howard S. Cullman,
Chairman.

New York, September 1, 1949

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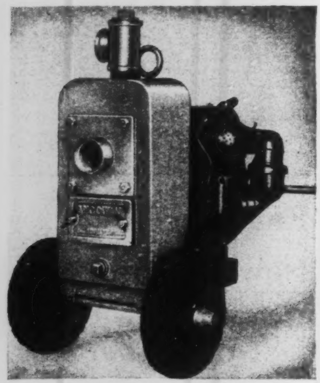

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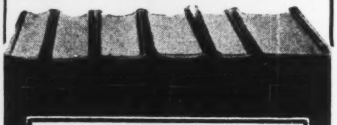

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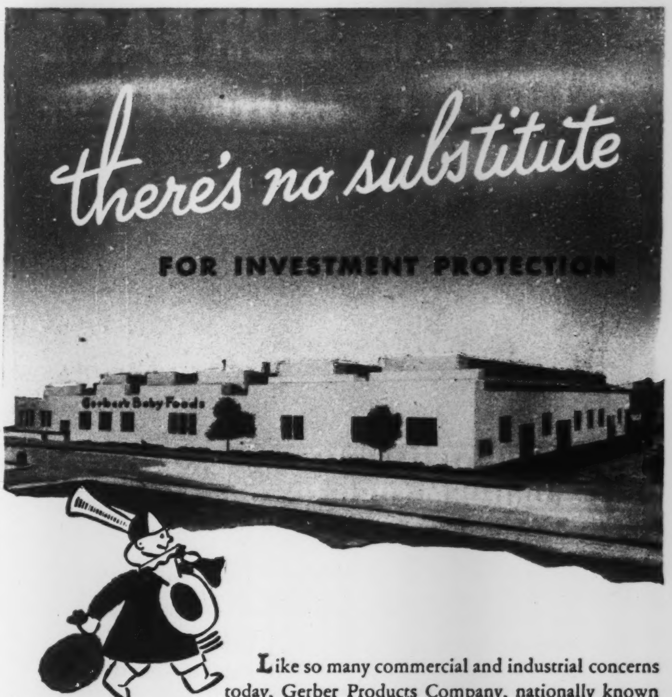

Like so many commercial and industrial concerns today, Gerber Products Company, nationally known makers of baby foods, selected "Automatic" Sprinkler investment protection for their modern plant in Oakland, California. Their choice as you'll understand from the following, was a wise one; for in addition to safeguarding the lives of some 600 valued employees, "Automatic" Sprinkler protection is remarkable from an investment point of view. The sprinkler installation in this case allowed for immediate insurance premium reductions of $24,000.00 annually... savings which will amortize the cost of protection in about 4½ years, following which annual dividends will continue to accumulate.

This particular illustration is not unusual, for depending upon the risk, insurance savings of upward to 90% may be realized through the installation of "Automatic" Sprinkler protection. It's good reason why thousands of business executives throughout the country specify multi-value fire protection with "Automatic" Sprinklers, *an important investment today... perhaps welcomed protection tomorrow.*

TYPICAL "Automatic" Sprinkler PROTECTED PROPERTIES

Industrial Plants
Storage - Warehousing
Mercantiles
Piers - Wharves
Aviation Properties
Hospitals - Institutions
Hotels - Apartments
Schools - Colleges
Offices - Public Buildings

"Automatic" FIRE-FOG provides positive protection for severe fire hazards

"AUTOMATIC" SPRINKLER CORPORATION OF AMERICA
YOUNGSTOWN 1, OHIO

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FOR INVESTMENT PROTECTION
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SEAL the SURFACE to PROTECT the BASE

STANDARD STEEL PRESSURE DISTRIBUTOR GIVES UNIFORM CURB-TO-CURB SURFACING

Uniform Pressure and Temperature Along the Entire Spray Bar Assures Accurate Application and Proper Penetration of Material.

Proper surfacing is the solution to withstanding winter freezes. Water that penetrates to sub-base causes heavy damage year after year to roads not correctly and uniformly surfaced from curb to curb. With the Standard Steel Model 424 Distributor there's rarely a bad spot in a mile of coating. Faster operation—no delays due to tinkering, dismantling and cleaning spray bar, or warm-up time. For primary construction, this equipment far excels all competitive makes. Let us give you the facts on "Competitive Tests".

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Keep up with this lively market through . . .

The ENR Construction Daily
330 W. 42nd St., New York 18, N. Y.

Price—$15 per month.

OFFICIAL PROPOSALS

Bids: October 3, 1949 (317)

Trunk Sewer Extension

ILLINOIS, ROCKFORD — The Sanitary District of Rockford, 3300 Kishwaukee Street.

Sanitary Sewers in Quadrant #1 totaling 3.2 miles of 8" to 21" diameter pipe, 1,000 feet underdrains, 12,553 feet concrete cradle encasement, 2,394 cu. yds. rock excavation, 50 manholes, etc.

Bids close Monday, October 3, 1949 at 1:00 P.M., Central Standard Time. Cash, bidder's bond or certified check for 5% of bids. Engineer: Arnold Lundgren, 1234 Fourth Ave., Rockford; Consulting Engineers: Greeley and Hansen, 220 S. State St., Chicago 4. Plans and specifications available upon $20.00 deposit at Sanitary District office, which sum is refundable to bona fide bidders.

THE SANITARY DISTRICT
OF ROCKFORD
H. A. Riedesel, District Engineer

Bids: September 6, 1949 (325)

Furnishing and Delivering Cast Iron Pipe and Cast Iron Fittings

WASHINGTON SUBURBAN SANITARY COMMISSION

Sealed proposals for furnishing and delivering approximately 750 tons of Cast Iron Pipe and Cast Iron Fittings will be received in the office of the Purchasing Agent of the Washington Suburban Sanitary Commission, Hamilton St., Hyattsville, Md. until Tuesday September 6th, 1949 at which time and place they will be publicly opened and read.

Lists of the pipe and fittings may be obtained from W. R. Douglas, Purchasing Agent of the Commission, Hyattsville, Md.

Dwight B. Galt, Chairman
Leland G. Worthington
Warren Browning
Commissioners.

Bids: September 8, 1949 (329)

Construction of Road

STATE OF NEW JERSEY
STATE HIGHWAY DEPARTMENT
TRENTON

NOTICE IS HEREBY GIVEN that sealed bids will be received by the State Highway Commissioner for:

MYERSVILLE ROAD

Construction of Myersville Road from Long Hill Road to Swamp Road, Passaic Township, Morris County, Federal Aid Secondary Project No. S-95(1). Length 0.784 miles. The principal items of construction are:

Estimated:

12,745	cu. yds.	Earth Excavation
27,606	gals.	Bituminous Material
13,145	sq. yds.	Macadam Base Course (4" thick)
13,145	sq. yds.	Modified Penetration Macadam (3" thick) (except Bituminous Material)
13,145	sq. yds.	Bituminous Concrete pavement Type "A" or "T", (1" thick)
2,413	lin. ft.	Drainage
3,197	lin. ft.	Concrete Curb

Bids for the above will be received at the office of the State Highway Department, Room 102, State House Annex, Trenton, N. J., on Thursday, September 8, 1949 at ten o'clock (10:00 A. M.—EASTERN STANDARD TIME), eleven o'clock (11:00 A. M.—DAYLIGHT SAVING TIME), and will be opened and read immmediately thereafter.

The receipt and opening of bids is subject to the proper qualification of the bidder in accordance with the provisions of the prequalification law and the regulations adopted by the State Highway Commissioner. Bidders must also submit a revised financial statement and statement of plant and equipment with their bid.

NOTE: The proposed project is a "Federal Aid Secondary Project" authorized by the provisions of Title 27 of the Revised Statues of New Jersey and Supplements and by Sections 2, 3 and 4, P. L. 521, 78th Congress, and is to be performed in accordance with the special provisions and requirements of the Federal Works Agency,

(Continued on page 439)

OFFICIAL PROPOSALS

(Continued from page 438)

Public Roads Administration, as outlined in the specifications, which provisions require that labor be employed from lists furnished by the State Employment Service, 30 Speedwell Avenue, Morristown, N. J. The attention of bidders is directed to the special provisions covering subletting or assigning the contract. The minimum wage paid to all unskilled labor employed on this contract shall be 65¢ per hour. The minimum wage paid to all intermediate grade labor employed on this contract shall be 75¢ per hour. The minimum wage paid to all skilled labor employed on this contract shall be $1.25 per hour.

Drawings, specifications and form of bid, contract and bond for the proposed work are on file in the office of the State Highway Department, Trenton, N. J., and may be inspected by prospective bidders during office hours. Plans will be furnished on a deposit of Ten Dollars ($10.00) for each set of plans upon application to A. Lee Grover, Chief Clerk, State Highway Department, Room 102, State House Annex, Trenton, N. J. Bids must be made upon the standard proposal forms in the manner designated in the standard State Highway specifications and must be enclosed in sealed special addressed envelopes bearing the name and address of the bidder and work bid upon on the outside, and must be accompanied by a certified check drawn to the order of the Treasurer of the State of New Jersey for not less than ten percent (10%) of the amount of the bid, provided that the said certified check shall not be less than $500.00 nor more than $20,000.00 and must be delivered at the above place on or before the hour named. Copies of the standard proposal forms and special addressed envelopes will be furnished on application. Bids not enclosed in sealed special addressed envelopes will be considered informal and will not be opened. The right is reserved to reject any or all bids.

Signed: Spencer Miller, Jr.
State Highway Commissioner

Bids: September 30, 1949 (328)

Reinforced Concrete Culvert

Notice to Contractors
Extension Poor House Run Flood Control Project
York, Pennsylvania

Sealed bids for the construction of a reinforced concrete culvert ten feet (10′) high and eight and one-half feet (8½′) wide inside by ten hundred seventy feet (1070′) long, will be received by City Council in City Hall, City of York, York County, Pa. until 9:30 A.M., E.S.T., September 30, 1949, and then publicly opened and read aloud at a regular meeting of Council.

The Information for Bidders, Form of Contract, Plans and Specifications may be examined at the office of the City Engineer, York, Pa. Copies thereof may be obtained at the said office upon payment of twenty dollars ($20.00) for each set. Any bidder upon returning such set in good condition, will be refunded his payment and any non-bidder upon returning such set promptly will be refunded fifteen dollars ($15.00).

The City Council of the City of York, Pa. reserves the right to waive any informalities in, or to reject any or all bids.

A certified check made payable to the order of City Treasurer, York, Pa. in the amount of five per cent (5%) of the base bid, must be deposited by each bidder with his bid as a guarantee that in case the contract is awarded to him, that he will, within five (5) days thereafter, execute such contract and furnish a performance bond in the amount of the contract and satisfactory to the City Council.

An additional bond of fifty per cent (50%) of the accepted bid is required as security for the payment of all persons performing labor and furnishing materials in connection therewith, in accordance with "Third Class City Law".

No bidder may withdraw his bid within thirty (30) days after the date set for the opening thereof. Any bid may be withdrawn prior to the above scheduled time for opening of Bids or authorized postponement thereof.

Fred A. Schiding
Director of Streets & Public Improvements, York, Pennsylvania

Dated: August 19, 1949
William E. Weigle
City Engineer

(Continued on page 440)

The Morris PORTABLE DREDGE
Is EASILY MOVED From Job to Job

Does Your Dredging
at Surprisingly Low Cost

Engineers recommend the Morris Portable Dredge because it can be dismantled quickly and moved from one job to another with minimum expense. Does its work rapidly on inland jobs often inaccessible to regular dredging equipment. Operates with only one man, requires only two or three men for manipulating the pipe line.

You Can Use the Morris Portable Dredge on Many Inland Jobs

It cleans water storage reservoirs . . . Deepens lakes and channels . . . Restores eroded beaches . . . Fills in undesirable lowlands . . . Beautifies parks and lakes. It does not disturb solids as much as other dredges . . . nor does it cause excessive turbidity. In fact, in most cases, reservoir water is usable even during the dredging operations.

Order a Morris Portable Dredge Now

We shall be glad to send one of our experienced hydraulic dredge engineers to discuss your dredging problems with you. He will recommend the purchase of a dredge only if its use is sound, practical and economical.

Should you require a dredge, we can design and build it now complete with either electric, gasoline or Diesel engine . . . and make installation of dredge and piping all ready for operation. Furthermore, we shall furnish an operator for an initial period of time until your own dredge operator learns operation and maintenance of the dredge.

Get Full Information About Portable Dredges

Write us today for Bulletin 177 which illustrates the Portable Dredge and a wide range of other dredges.

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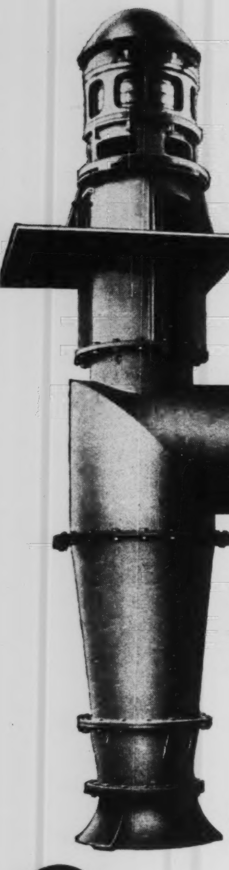
for your MAN SIZE pumping jobs

Economy
AXIAL FLOW PUMPS



Especially suited for condenser circulation, dewatering, drainage and other large-volume jobs. Capacities up to 200,000 G.P.M.

For low-head, large volume pumping, Economy Axial Flow Pumps are unsurpassed by any other type of efficient pumping equipment. Designed for either horizontal or vertical settings, these pumps are simple in design, compact in construction, and low in cost. Axial Flow propellers are accurately machined, hand finished all over and balanced for smooth, trouble-free operation. Pumps can be furnished with oil or grease lubricated metallic bearings or water lubricated rubber bearings.

For complete details write Dept. CB-9 for Bulletin G845.

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GROUT HOLES

Tinney Drilling Co.
Grafton, W. Va.

OFFICIAL PROPOSALS

(Continued from page 439)

Bids: September 12, 1949 (322)

Remodeling Incinerator

NOTICE TO CONTRACTORS

Sealed bids for the Remodeling of the Incinerator of the Village of Valley Stream, Nassau County, New York, will be received by the Board of Trustees, at the office of the Village Clerk, Village Hall, Village of Valley Stream, Nassau County, New York, on September 12th, 1949, until eight P.M. (E.D.T.) and will be publicly opened and read aloud at a meeting of the Board of Trustees, Village of Valley Stream, Nassau County, New York.

The Information for Bidders, Form of Bid, Form of Contract, Specifications, Form of Performance Bond and Plans, may be examined at the office of the Village Clerk, Village Hall, Village of Valley Stream, Nassau County, N. Y., or at the office of the Consulting Engineer, Henry W. Taylor, 11 Park Place, New York, N. Y. and copies thereof can be obtained upon payment of Twenty-five Dollars ($25.00) for each set, checks made payable to Fred A. Clemenz, Village Treasurer. A refund of Fifteen Dollars ($15.00) will be made for each set to each bidder or non-bidder upon return of such set in good condition within ten **(10) days after the receipt of bids.**

The Village of Valley Stream reserves the right to waive any informalities in any bid, to accept any bid, or to reject any or all bids.

Each bidder must deposit with his bid security in an amount of not less than five percentum (5%) of the base bid in the form and subject to the conditions provided in the Information for Bidders. Such check is to be made payable to Fred A. Clemenz, Village Treasurer.

No bidder may withdraw his bid after acceptance thereof by the Village of Valley Stream, or within forty-five (45) days after the actual date of the opening thereof.

FLETCHER CHALMERS
Village Clerk

Dated August 15, 1949

Bids: September 20, 1949 (332)

General Construction

SEALED PROPOSALS will be received by the President of the Levy Court of New Castle County, Room 133, Public Building, Wilmington, Delaware until 11:00 A.M. Daylight Saving Time on September 20th, 1949 and at that time and place, publicly opened for contracts involving the following approximate quantities:

CONTRACT SD-21A
N. BELLEVUE MANOR
Brandywine Hundred
New Castle County

450	cu. yds.	Excavation
370	tons	Waterbound Macadam
160	tons	Bituminous Concrete
115	lin. ft.	15" R. C. Pipe
50	lin. ft.	30" R. C. Pipe
370	sq. yds.	Cement, Concrete Gutter
890	lin. ft.	Int. Curb & Gutter
4	each	Catch Basins
5	each	Adjusted Manholes
2,000	lbs.	Castings
90	cu. yds.	Topsoil
0.15	acres	Seeding

CONTRACT SD-23
WILMINGTON MANOR
New Castle Hundred
New Castle County

9,035	cu. yds.	Excavation
725	cu. yds.	Selected Borrow
7,200	tons	Waterbound Macadam
1,725	tons	Bituminous Concrete
120	sq. yds.	Patching
2.5	cu. yds.	Cement, Concrete Masonry
125	pounds	Reinforcing Steel
15	lin. ft.	12" R. C. Pipe
15	lin. ft.	15" R. C. Pipe
200	lin. ft.	18" R. C. Pipe
70	lin. ft.	Relaid 12" R. C. Pipe
150	lin. ft.	4" Vit. Clay Pipe
675	sq. yds.	6" Cement, Concrete Gutter
19,750	lin. ft.	Integral Curb & Gutter
6	each	Catch Basins
1	each	Special Catch Basin
39	each	Adjusted Manholes & Lampholes
2,870	pounds	Castings
5,300	sq. yds.	Topsoil
1.5	acres	Seeding

CONTRACT SD-24
WILMINGTON MANOR
New Castle Hundred
New Castle County

480	cu. yds.	Excavation

(Continued on page 441)

OFFICIAL PROPOSALS

(Continued from page 440)

170	cu. yds.	Selected Borrow
575	tons	Waterbound Macadam
1,880	tons	Bituminous Concrete
25	sq. yds.	Patching
3	cu. yds.	Cement, Concrete Masonry
223	pounds	Reinforcing Steel
260	lin. ft.	18" R. C. Pipe
435	sq. yds.	6" Cement, Concrete Gutter
3,610	lin. ft.	Integral Curb & Gutter
5	each	Catch Basins
1	each	Special Catch Basin
31	each	Adjusted Manholes & Lampholes
2,460	pounds	Castings
325	sq. yds.	Topsoil
0.2	acres	Seeding

CONTRACT SD-25
LYNDALIA
Christiana Hundred
New Castle County

1,500	cu. yds.	Excavation
2,125	tons	Waterbound Macadam
500	tons	Bituminous Concrete
70	lin. ft.	15" R. C. Pipe
630	lin. ft.	29" x 18" C. M. Arch Pipe
220	sq. yds.	6" Cement, Concrete Gutter
5,760	lin. ft.	Integral Curb & Gutter
9	each	Catch Basins
6	each	Adjusted Manholes
4,500	pounds	Castings
175	cu. yds.	Topsoil
0.5	acres	Seeding
25	sq. yds.	Sodding

Attention is called to the Special Provisions in the proposal, specifications and contract agreement.

Performance of contract shall commence within ten (10) days after the execution of the contract and be completed as specified.

Monthly payments will be made for ninety (90) per cent of the construction completed each month.

Bidders must submit proposals upon forms provided by the County Engineer.

Each proposal must be accompanied by a surety bond, certified check, or money, to the amount of at least ten (10) per centum of the total amount of the proposal.

The envelope containing the proposal must be marked "Suburban Development Contract No. ....

The contract will be awarded or rejected within twenty (20) days from the date of opening **proposals.**

The right is reserved to reject any or all bids.

Complete sets and plans may be obtained after September 6, 1949 upon the receipt of two dollars ($2.00) for each contract, which will not be refunded.

Make checks payable to the Levy Court of New Castle County.

LEVY COURT OF NEW CASTLE COUNTY
By: John I. Cahalan, County Engineer

Bids September 8, 1949 (331)

Construction of Finderne Avenue

STATE OF NEW JERSEY
STATE HIGHWAY DEPARTMENT

NOTICE IS HEREBY GIVEN that sealed bids will be received by the State Highway Commissioner for:

FINDERNE AVENUE

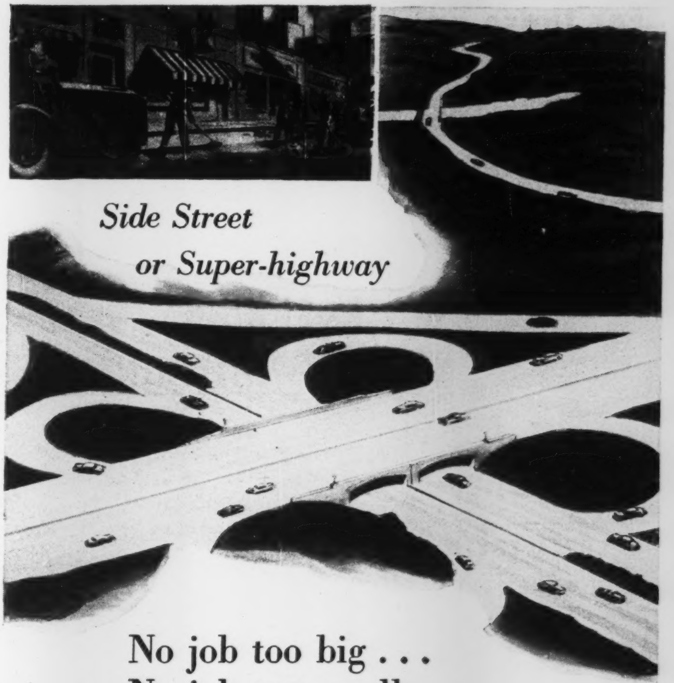
Construction of Finderne Avenue from 500′ north of New Jersey Turnpike to State Highway Route 28, Bridgewater Township, Somerset County, Federal Aid Secondary Project No. S-117(2). Length 0.358 miles. The principal items of construction are:

Estimated:

3,008	cu. yds. Excavation, unclassified
4,522	sq. yds. 8" Reinforced Concrete Pavement
4,050	sq. yds. Penetration Macadam Surface (3" thick) (except Bituminous Material)
10,631	gals. Bituminous Material
1	Unit Traffic Signal, Installation Complete
425	lin. ft. Drainage

Bids for the above will be received at the office of the State Highway Department, Room 102, State House Annex, Trenton, N. J., on Thursday, September 8, 1949 at ten o'clock (10:00 A.M.—EASTERN STANDARD TIME), eleven o'clock (11:00 A.M.—DAYLIGHT SAVING TIME), and

(Continued on page 442)



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OFFICIAL PROPOSALS

(Continued from page 441)

will be opened and read immediately thereafter.

The receipt and opening of bids is subject to the proper qualification of the bidder in accordance with the provisions of the prequalification law and the regulations adopted by the State Highway Commissioner. Bidders must also submit a revised financial statement and statement of plant and equipment with their bid.

NOTE: The proposed project is a "Federal Aid Secondary Project" authorized by the provisions of Title 27 of the Revised Statutes of New Jersey and Supplements and by Sections 2, 3 and 4, P. L. 521, 78th Congress, and is to be performed in accordance with the special provisions and requirements of the Federal Works Agency, Public Roads Administration, as outlined in the specifications, which provisions require that labor be employed from lists furnished by the State Employment Service, 149 West Main Street, Somerville, N. J. The attention of bidders is directed to the special provisions covering subletting or assigning the contract. The minimum wage paid to all unskilled labor employed on this contract shall be 65¢ per hour. The minimum wage paid to all intermediate grade of labor employed on this contract shall b 75¢ per hour. The minimum wage paid to all skilled labor employed on this contract shall be $1.25 per hour.

Drawings, specifications and form of bid, contract and bond for the proposed work are on file in the office of the State Highway Department, Trenton, N. J., and may be inspected by prospective bidders during office hours. Plans will be furnished on a deposit of Ten Dollars ($10.00) for each set of plans upon application to A. Lee Grover, Chief Clerk, State Highway Department, Room 102, State House Annex, Trenton, N. J. Bids must be made upon the standard proposal forms in the manner designated in the standard State Highway specifications and must be enclosed in sealed special addressed envelopes bearing the name and address of the bidder and work bid upon on the outside, and must be accompanied by a certified check drawn to the order of the Treasurer of the State of New Jersey for not less than ten percent (10%) of the amount of the bid, provided that the said certified check shall not be less than $500.00 nor more than $20,000.00 and must be delivered at the above place on or before the hour named. Copies of the standard proposal forms and special addressed envelopes will be furnished on application. Bids not enclosed in sealed special addressed envelopes will be considered informal and will not be opened. The right is reserved to reject any or all bids.

Signed: Spencer Miller, Jr.
State Highway Commissioner

Bids: October 3, 1949 (316)

Sewage Treatment Plant Additions

ILLINOIS, ROCKFORD—THE SANITARY DISTRICT OF ROCKFORD, 3300 Kishwaukee Street.

CONTRACT A—STUCTURES AND EQUIPMENT—One 55′ diameter digester, four 75′ diameter sedimentation tanks, sludge pumping station, 3 control chambers, drainage building, underground piping, excavation for 3 sludge lagoons and ditch, roads and sidewalks, miscellaneous work items, etc. Work includes approximately 81,500 cu. yds. excavation, 3,300 cu. yds. concrete, 400,000# steel reinforcement, 20,500# structural steel, misc. steel and wrought iron, 4,700 bbls. cement, iron castings, steel floor gratings, meters, valves, piping, fencing and other items of material and equipment.

CONTRACT C—ELECTRICAL WORK

Bids close Monday, October 3, 1949 at 1:00 P.M. Central Standard Time. Cash, bidder's bond or certified check for 5% of bids. Engineers: Greeley and Hansen, 220 S. State St., Chicago 4. Plans and specifications available upon $20.00 deposit at Sewage Treatment Plant, Rockford, or Engineers' Office, Chicago, which sum is refundable to bona fide bidders.

THE SANITARY DISTRICT
OF ROCKFORD
H. A. Riedesel, District Engineer

(Continued on page 443)

OFFICIAL PROPOSALS

(Continued from page 442)

Bids: September 15, 1949 (330)

Re-Advertisement for Bridge

STATE OF NEW JERSEY
STATE HIGHWAY DEPARTMENT
TRENTON

RE-ADVERTISEMENT

NOTICE IS HEREBY GIVEN that sealed bids will be received by the State Highway Commissioner for:

SEA BRIGHT BRIDGE

Construction of the Sea Bright Bridge over the South Branch of Shrewsbury River in the Boroughs of Sea Bright and Rumson, Monmouth County, Federal Aid Secondary Project No. S-111(1). The work consists of a double leaf bascule span and nine fixed spans. The principal items of construction are:

Estimated:

1,640,000	lbs. Structural Steel
410,000	lbs. Reinforcement Steel
5,250	cu. yds. Concrete
20,000	lin. ft. Treated Timber Piles
72,000	lbs. Machinery
	L.S. Bascule span Roadway & Sidewalk Flooring
	L.S. Counterweights
	L.S. Electrical Equipment

Bids for the above will be received at the office of the State Highway Department, Room 102, State House Annex, Trenton, N. J., on Thursday, September 15, 1949 at ten o'clock (10:00 A.M. — EASTERN STANDARD TIME), eleven o'clock (11:00 A.M.—DAYLIGHT SAVING TIME) and will be opened and read immediately thereafter.

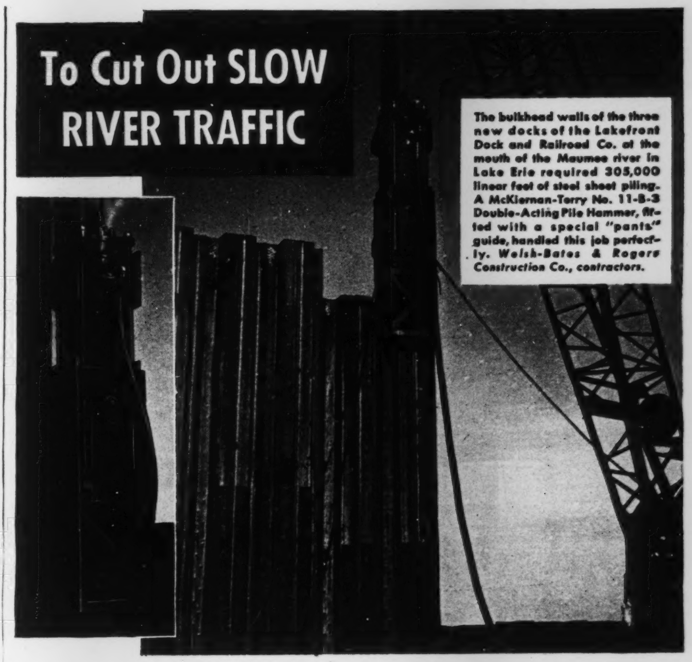
The receipt and opening of bids is subject to the proper qualification of the bidder in accordance with the provisions of the prequalification law and the regulations adopted by the State Highway Commissioner. Bidders must also submit a revised financial statement and statement of plant and equipment with their bid.

NOTE: The proposed project is a 'Federal Aid Secondary Project" authorized by the provisions of Title 27 of the Revised Statutes of New Jersey and Supplements and by Sections 2, 3 and 4, P. L. 521, 78th Congress, and is to be performed in accordance with the special provisions and requirements of the Federal Works Agency, Public Roads Administration, as outlined in the specifications, which provisions require that labor be employed from lists furnished by the State Employment Service, 48 East Front Street, Red Bank, New Jersey. The attention of bidders is directed to the special provisions covering subletting or assigning the contract. The minimum wage paid to all unskilled labor employed on this contract shall be 65¢ per hour. The minimum wage paid to all intermediate grade of labor employed on this contract shall be 75¢ per hour. The minimum wage paid to all skilled labor employed on this contract shall be $1.25 per hour.

Drawings, specifications and form of bid, contract and bond for the proposed work are on file in the office of the State Highway Department, Trenton, N. J., and may be inspected by prospective bidders during office hours. Plans will be furnished on a deposit of Ten Dollars ($10.00) for each set of plans upon application to A. Lee Grover, Chief Clerk, State Highway Department, Room 102, State House Annex, Trenton, N. J. Bids must be made upon the standard proposal forms in the manner designated in the standard State Highway specifications and must be enclosed in sealed special addressed envelopes bearing the name and address of the bidder and work bid upon on the outside, and must be accompanied by a certified check drawn to the order of the Treasurer of the State of New Jersey for not less than ten percent (10%) of the amount of the bid, provided that the said certified check shall not be less than $500.00 nor more than $20,000.00 and must be delivered at the above place on or before the hour named. Copies of the standard proposal forms and special addressed envelopes will be furnished on application. Bids not enclosed in sealed special addressed envelopes will be considered informal and will not be opened. The right is reserved to reject any or all bids.

Signed: Spencer Miller, Jr.
State Highway Commissioner

(Continued on page 444)



To Cut Out SLOW RIVER TRAFFIC

The bulkhead walls of the three new docks of the Lakefront Dock and Railroad Co. at the mouth of the Maumee river in Lake Erie required 305,000 linear feet of steel sheet piling. A McKiernan-Terry No. 11-B-3 Double-Acting Pile Hammer, fitted with a special "pants" guide, handled this job perfectly. Welsh-Bates & Rogers Construction Co., contractors.

These long-needed docks enable the lanky lake vessels to pick up coal loads right at the lake front, without the tedious, bridge-hampered trip five to seven miles up the river to Toledo, formerly necessary.

Fitted with a specially designed guide to insure accuracy, this powerful 11-B-3 McKiernan-Terry Hammer, packing a 19,500 foot-pound wallop, was the contractors' natural choice for handling the big steel sheets.

For engineers and contractors all know that the McKiernan-Terry standard line of ten double-acting and five single-acting pile hammers and two double-acting pile extractors can always supply a piece of equipment of the power needed for any specified pile-handling operation.

McKIERNAN-TERRY VERSATILITY

Coal and ore bridges, bulk material unloaders, bridge operating mechanisms, hoists and marine equipment are among the many other important products of McKiernan-Terry engineering and manufacturing skill that are performing important service to industry, the railroads and our government.

FOR FULL DATA

Write for free literature on the McKiernan-Terry line, giving specifications and pictures of these hammers on varied jobs. Send request on your business letterhead today.

MK 268 A

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Restoring Disintegrated Concrete
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Way ahead in design . . . in construction . . . in PROFITABLE general duty service! That's your next motor grader . . . that's your new WARCO 4D-76. Put these "brass tacks" advantages to work for you: completely cab-controlled movement of blade from 90° elevation on one side to 90° on the other . . . 360° blade rotation without removing scarifier or teeth . . . sliding moldboard for extra reach . . . big interchangeable tires all around for effective traction and flotation . . . powerful 76 H.P. diesel engine . . . extra working clearances front and rear . . . less operator fatigue . . . mechanical steering, with power booster.

Let your WARCO dealer tell you . . . show you . . . prove to your own satisfaction that the new WARCO 4D-76 is your most practical, most profitable general-duty motor grader investment for today . . . and for the future.

compare . . . select the WARCO best suited to your needs

All controls are in front of cab, within easy reach of operator

		Without Cab or Scarifier Approximate Weights in Lbs.			
	Model No. and HP	Total	On Front Wheels	On Rear Wheels	Blade Pressure
HEAVY DUTY	4D-100	22,879	6,617	16,262	11,900
GENERAL DUTY	4D-76	21,356	6,279	15,077	11,205

W. A. RIDDELL CORP. • *Bucyrus, Ohio*

BUILDERS OF WARCO MOTOR GRADERS • HERCULES ROAD ROLLERS

HEADS
you win
TAILS
you win

In other words, how can you lose? When you get the widest possible publicity for your proposed work you can assure yourself of receiving the lowest possible bid consistent with good work. Thus you can do more with the money allotted to a construction job—or have money left over for some other needed work.

Contractors, the country over, check the OFFICIAL PROPOSAL SECTION of ENGINEERING NEWS-RECORD each week in order to make bids on work to be done. For over a half century, Federal, State and Municipal governments have advertised in this Section to secure the lowest possible bids from the highest type of bidder.

The extremely low price of $1.00 per line for advertising in this Section is but a fraction of the savings to be realized through its use.

Official Proposals Section

ENGINEERING NEWS-RECORD

330 W. 42nd St., New York 18, New York

OFFICIAL PROPOSALS

Bids: September 15, 1949 (338)

Construction of Parkway

STATE OF NEW JERSEY
STATE HIGHWAY DEPARTMENT
TRENTON

NOTICE IS HEREBY GIVEN that sealed bids will be received by the State Highway Commissioner for:

ROUTE 4 PARKWAY, SECTIONS 2E & 4D, PAVING

Construction of Route 4 Parkway, Sections 2E and 4D, Paving, from Port Reading Railroad to Inman Avenue, Woodbridge Township, Middlesex County, Federal Project No. U-188(16). Length 2.973 miles.

Roadway Items

Estimated:

19,350	cu. yds. Roadway Excavation-Earth
5,800	cu. yds. Borrow Excavation
24,400	sq. yds. Stabilized Turf Shoulders
35,380	sq. yds. 3″ Macadam Base Course
36,400	sq. yds. 4″ Bit. Pen. Macadam Courses
434	tons Bituminous Concrete Pavement
99,000	sq. yds. 8″ Plain Conc. Pavement Surface

Bridge Items

218	cu. yds. Concrete in Structures
6,180	lbs. Rein. Steel in Structures
7,325	lbs. Structural Steel

Bids for the above will be received at the office of the State Highway Department, Room 102, State House Annex, Trenton, N. J., on Thursday, September 15, 1949 at ten o'clock (10:00 A. M.—EASTERN STANDARD TIME), eleven o'clock (11:00 A. M.—DAYLIGHT SAVING TIME), and will be opened and read immediately thereafter.

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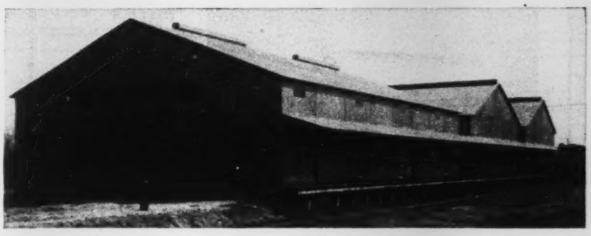
NOTE: The proposed project is a "Federal Aid Project" authorized by the provisions of Title 27, of the Revised Statutes of New Jersey and supplements and by Sections 2, 3 and 4, P. L. 521, 78th Congress and is to be performed in accordance with the special provisions and requirements of the Bureau of Public Roads, Department of Commerce, as outlined in the specifications, which provisions require that labor be employed from lists furnished by the State Employment Service, Cor. Maple and Fayette Streets, Perth Amboy, N. J. The attention of bidders is directed to the special provisions covering subletting or assigning the contract. The minimum wage paid to all unskilled labor employed on this contract shall be 65¢ per hour. The minimum wage paid to all intermediate grade of labor employed on this contract shall be 75¢ per hour. The minimum wage paid to all skilled labor employed on this contract shall be $1.25 per hour.

Drawings, specifications and form of bid, contract and bond for the proposed work are on file in the office of the State Highway Department, Trenton, N. J., and may be inspected by prospective bidders during office hours. Plans will be furnished on a deposit of Ten Dollars ($10.00) for each set of plans upon application to A. Lee Grover, Chief Clerk, State Highway Department, Room 102, State House Annex, Trenton, N. J. Bids must be made upon the standard proposal forms in the manner designated in the standard State Highway specifications and must be enclosed in sealed special addressed envelopes bearing the name and address of the bidder and work bid upon on the outside, and must be accompanied by a certified check drawn to the order of the Treasurer of the State of New Jersey for not less than ten percent (10%) of the amount of the bid, provided that the said certified check shall not be less than $500.00 nor more than $20,000.00 and must be delivered at the above place on or before the hour named. Copies of the standard proposal forms and special addressed envelopes will be furnished on application. Bids not enclosed in sealed special addressed envelopes will be considered informal and will not be opened. The right is reserved to reject any or all bids.

Signed: Spencer Miller, Jr.
State Highway Commissioner

Prompt Delivery on

STEEL BUILDINGS



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- *Custom Built*
- *Insulated if Desired*

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- Gratings
- Ladders
- Platforms
- Safety Cages
- Ventilators

Allied Steel is in a position at the present time to furnish *prompt delivery* on Steel Buildings, Structural Steel Fabrication and Steel Accessories.

Allied will completely engineer your special building requirements from analysis of your need to placing the last piece of steel.

Allied buildings can be furnished insulated; they are flexible, can be lengthened or shortened; afford nearly 100 percent salvage; are portable; have low initial investment and low cost maintenance; are fire resistant and weathertight.

ALLIED PRODUCTS STEEL

WRITE FOR ALLIED'S CATALOG

ALLIED STEEL PRODUCTS CORP.

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ENGINEERING NEWS-RECORD

will publish it's 23rd Annual COSTS AND TRENDS YEARBOOK

March 23, 1950

"The standard, year-round-reference on basic construction costs and trends"

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Closing date—March 2, 1950

Extra copies may be reserved by writing:
R. F. Boger, *Publisher*
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330 W. 42nd Street, New York 18, N. Y.
Price—$2.00

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SILAS MASON COMPANY, INC.
SHREVEPORT, LA.

TUNNELS - INDUSTRIAL PLANTS AND OTHER
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ACCURATE
DEPENDABLE
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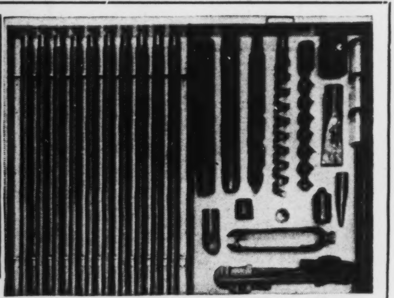
INFORMATION



ACKER SOIL SAMPLING KIT

- Twelve soil and earth sampling tools in handy steel box.
- Can be carried in any automobile.
- Depths limited only to driving power of sledge or maul.

• Thirty years' experience has proved these tools will recover accurate samples from practically all earth materials.

• MANY USES include aluminum silicate deposits—brick and clay materials—foundation test borings—gold bearing sands—kaolin and clay for ceramics—sand and gravel pits—subgrade testing for highways and airfield runways—base materials.

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PROPOSALS, $1.00 a line an insertion.

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BOX NUMBERS care publication New York, Chicago or San Francisco offices count as 1 line additional in undisplayed ads.

DISCOUNT of 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

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The advertising rate is $11.50 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

AN ADVERTISING INCH is measured ⅞ inch vertically on one column, 3 columns—30 inches —to a page. E.N.R.

NEW ADVERTISEMENTS received by September 2nd appear in September 15th issue subject to limitation of space available.

REPLIES (Box No.): Address to office nearest you
NEW YORK: 330 W. 42nd St., (18)
CHICAGO: 520 S. Michigan Ave. (11)
SAN FRANCISCO: 68 Post St. (4)

POSITIONS VACANT

WANTED—ENGINEERS, Architects, Draftsmen experienced in the design of sewers, sewage treatment plants, water treatment plants and industrial buildings. Also engineers to supervise construction. State qualifications, experience. Salary requirements and date available. P-1155, Engineering News-Record.

ESTIMATOR—FOR General Building Contractor. We need two men who are qualified to prepare quantity surveys covering items like excavation, concrete, forms, brick work, tile partitions, glazed tile, carpentry, etc. Knowledge of pricing not necessary. We figure only building projects running over $5,000,000.00, mostly hospital construction. Will pay top salary for qualified men. Only experienced, high type men considered. Write in confidence giving education, experience, age, salary desired, when available. Fleisher Engineering and Construction Co., P. O. Box 68, Kensington Station, Buffalo, New York.

UNUSUAL OPPORTUNITY — Graduate Civil Engineer, age 35 or under, wanted for responsible permanent position with large manufacturer of surveying and drafting instruments and associated equipment and supplies located in Chicago. Must have ability to quickly understand products of the type indicated and write accurate catalog descriptions, instruction sheets, use and care information, etc. Previous technical writing experience desirable but not necessary. Salary $3600 to $5000, depending upon length of training required. Box 9674, Engineering News-Record.

WANTED: AN experienced Engineer for a City of 22,000 population, salary $4,000.00 Address: Carl E. Pratt, Sr., Mayor, Hastings, Nebraska.

SHOP SUPERINTENDENT for medium-sized mid-western structural fabricating shop, specializing in bridge and building work. Applicant must be thoroughly experienced in production, have good working knowledge of shop equipment and have ability to handle and lead men. Good opportunity. P-9740, Engineering News-Record.

WANTED: EXPERIENCED Structural steel draftsman, location Oklahoma. Reply P-9547, Engineering News-Record.

WANTED: EXPERIENCED structural Draftsman for precast concrete plant. Must be able to prepare accurate shop drawings of a precast concrete roof deck on structural steel frame. Steady work. Good pay. State qualifications and salary desires. Arnold Stone Company, Greensboro, North Carolina.

WANTED: ESTIMATOR, heavy construction, knowledge of gunite work desired but not essential. Write stating age, experience, salary expected and when available. P-9776, Engineering New-Record.

CIVIL ENGINEER with 5 to 10 years experience in hydraulic and sanitary fields. Headquarters Chicago. Some traveling required. Give references, complete information on education and experience. Starting salary $400-$450. P-9791, Engineering News-Record.

WANTED: FIELD Engineer with strong background and experience in property and Right-of-Way surveys. Must be thoroughly qualified to supervise several field parties and coordinate work between field and office. Give experience in detail and salary expected. Location: Kansas. P-9802, Engineering News-Record.

(Continued on page 448)

THIS IS OUR 75th ANNIVERSARY TOO
1874-1949

CUNNINGHAM BROTHERS, INC.

GENERAL CONTRACTORS

BELOIT, WISCONSIN

We have an excellent opportunity in our organization for a man:

1. **Who is an executive**
2. **Thoroughly familiar with estimating**
3. **Who has assumed responsibility successfully**
4. **That prefers living in a small attractive mid-western city**
5. **Desiring a real future in security and financial independence with a company that has been respected by the industry continuously for Seventy-Five years.**

SEWAGE DISPOSAL PLANT OPERATOR
WANTED

With broad experience and ability to operate and take complete charge of a 125 m.g.d. modified aeration plant, (salary $6640-$7440 per year). Job will be filled after non-assembled competitive examination. Applications must be filed on required form before September 9, 1949. For further information write:

Civil Service Commission
Room 875, City Hall Philadelphia 7, Pa.

TRAINEE—SALES ENGINEER

Sales Trainee to learn the wellpoint business. Must be engineering graduate with sales personality, able to read and draw plans. Prefer man 25 to 35 years with experience on construction work and wet excavations. Send snapshot, resume, and advise salary desired.

P-9821, Engineering News-Record
330 W. 42nd Street, New York 18, N. Y.

CIVIL ENGINEER

as addition to the permanent staff of a major oil company. Duties include design and construction of town sites, industrial buildings, roads, foundations, oil refinery structures. Some knowledge of architectural design is desirable. Minimum qualifications are a degree and three years related experience.

Write giving age, education, marital status and detailed resume of experience.

Box 308-A
Radio City Station
New York 19, New York

STAFF ENGINEER

Electrical or Mechanical Engineer with degree and three to five years oil refinery experience. Must be familiar with design and construction of oil refinery process equipment, electric power plants and related projects. Field experience necessary.

This position is on the regular staff of a major oil company.

Write giving age, education, marital status and detailed experience resume.

Box 308-M
Radio City Station
New York 19, New York

Chief Civil Engineer
WANTED

Established West Coast Engineering firm needs qualified Graduate Civil Engineer to take charge of Civil Department. Thorough knowledge and wide experience required in Civil Engineering including grading, drainage, roads, railroads, and utility layouts for municipalities. In addition, applicant must possess ability to discuss and develop prospective work with municipal, county and state authorities. Furnish complete record with photo. Replies confidential.

P-9814, Engineering News-Record
621 S. Hope Street, Los Angeles, Calif.

STRUCTURAL DESIGNER
WANTED

Experienced in coal and ore bridges, dock cranes and material-handling equipment. Must be capable of preparing stress sheets and layout work for detailers. Permanent connection. Give qualifications, experience, and salary expected.

Address **A. J. Lichtinger,**
c/o THE WELLMAN ENGINEERING CO.
Cleveland 4, Ohio

POSITION AVAILABLE

Civil Engineer, 35 to 45 years old to supervise project engineers on building work, waste disposal and general civil engineering design for chemical company located in East. Furnish detailed resume of experience and education, also salary requirement, in reply.

P-9634, Engineering News-Record
330 W. 42nd Street, New York 18, N. Y.

SALES REPRESENTATIVE

Permanent position with opportunity for advancement for man with practical experience or knowledge of concrete design and operation of ready mix concrete plants helpful. To represent old line manufacturer of concrete hardeners, waterproofing, and technical treatments of concrete and masonry. Salary and Travel. Must be willing to travel extensively. Write fully giving details of your experience, salary desired, snapshot, etc. to

RW-9801, Engineering News-Record
520 N. Michigan Ave., Chicago 11, Ill.

POSITIONS AVAILABLE. Assistant Professor, young man, graduate in architecture or architectural engineering, with training in structures. Practical experience in architecture and structures desirable. To teach courses in structural design and to assist in coordinating architectural and structural designs. Starting salary, $3600 for 9 months, with possibility of summer teaching at the rate of $1200 for the quarter. Write to: Harold Bush-Brown, Director School of Architecture, Georgia Institute of Technology, Atlanta, Georgia.

POSITION VACANT

(Continued from page 447)

REINFORCING BAR Detailer for work in New York City. Preferably experienced in both detailing and estimating for reinforcing bar fabricators. Write experience fully stating also salary desired. P-9823, Engineering News-Record.

POSITIONS WANTED

PILOT WITH requirements—4300 flying hours. Desires permanent position. Will answer all requests. Owen C. Jones, 48415 Ford Road, Plymouth, Michigan.

CONSTRUCTION AND Maintenance Engineer. C.E. graduate. Broad experience in design, construction, maintenance, contracting, purchasing, etc., all types of commercial and industrial buildings. Former contractor, good business background. Speaks Spanish. Wishes position here or Latin America. PW-9589, Enginering News-Record.

DRAFTSMAN GENERAL, good structural. Also machinist, millwright and licensed embalmer. Want foreign work. PW-9579. Engineering News-Record.

STRUCTURAL ENGINEER — registered Indiana and Michigan, other registrations pending. Thirteen years Structural Engineering and Architectural experience includes power plants —commercial and industrial structures—stores and homes. Will consider working on fee—hourly-partnership-or salary basis. Write PW-9627, Engineering News-Record.

CONSTRUCTION SUPERINTENDENT — 28 years in complete charge of Projects for general contractors. Consisting of: Dirt and Concrete dikes and dams, Flood Walls, Pumping stations, paving, bridges, sewers, sewage disposal, water treatment and industrial plants, power houses and coffer dams. At present in charge of paving project. Married and will go anywhere. Available soon. PW-9632, Engineering News-Record.

EQUIPMENT SUPERINTENDENT: master mechanic, 25 years experience heavy construction, large spreads, 15 yrs. foreign experience. Can be used as equipment consultant. Prefers foreign work—anywhere. Harbors, airports, railroads, roads, industrial plants, etc. PW-9673, Engineering News-Record.

CAPABLE MAN desires connection with structural fabricating shop. Interested only in capacity of Chief Draftsman. PW-9614, Engineering News-Record.

ESTIMATOR-RIGGING-Printing presses. Machine tools. 25 years experience. PW-9687, Engineering News Record.

CONSTRUCTION SUPERINTENDENT And engineer, 17 years practical experience all phases public, industrial, commercial bldgs., bridge and road construction, married, clean record, prefer mid-west location. Address PW-9710, Engineering News-Record.

GENERAL OR Job Superintendent. 25 years experience: organizing, supervision, purchasing, estimating—sewers, disposal plants, water works, highways, tunnels, air bases, subways, industrial plants. PW-9746, Engineering News-Record.

PROJECT MANAGER: Gen. Supt. desires connection. 22 years experience. Registered Engr. 3-states. Dams-power plants-industrial bldgs. Hospitals-tunnels-bridges. Wharfs-docks-pile driving. Resume of experience and reference furnished upon request. Willing to travel. PW-9744, Enginering News-Record.

ACCOUNTANT, 40 wants responsible job with reliable company. Full experience in all phases of construction paper work including timekeeping, payroll, purchasing records, costs, material and equipment records, field office and general office books. Anywhere. J. J. Quirk, 433-101 Street, Brooklyn, N. Y. C.

STRUCTURAL ENGINEER, 25 years thorough responsible experience in design, checking, rigid frame analysis. Highest qualifications. PW-9755, Engineering News-Record.

CONSTRUCTION EXECUTIVE, thirty years sound experience, every phase of building and heavy construction, will terminate present connection January 1st or sooner. Interested in responsible position where scope requires high grade man. PW-9760, Engineering News-Record.

BUSINESS ASSOCIATE with small contractor in West or Southwest desired by graduate licensed Civil Engineer age 39 member A.S.C.E. with 15 years executive experience, handling architectural, engineering and construction contracts. PW-9669, Engineering News-Record.

SALARIED POSITIONS $3.500—$35,000

If you are considering a new connection communicate with the undersigned. We offer the original personal employment service (39 years recognized standing and reputation). The procedure, of highest ethical standards, is individualized to your personal requirements and develops overtures without initiative on your part. Your identity covered and present position protected. Send only name and address for details.

R. W. BIXBY, Inc., 272 Dun Bldg., Buffalo 2, N.Y.

POSITION WANTED

STRUCTURAL ENGINEER: M. ASCE, Registered, 38, Married, B.S., M.S., M.A., C.E. 12 years varied experience in Bridges, Buildings, Water Treatment Plants, Oil Refinery Structures and Equipment, and Engineering Teaching. At present employed by a foreign government as a Consultant. Available two weeks notice. Desires permanent position of responsible character. Will consider a teaching position PW-9781, Engineering News-Record.

GRADUATE CIVIL Engineer, with Law Degree. Six years professional experience, consisting of work with building materials dealer, structural design and specifications, and as manager of small precast concrete plant. Young, married, now studying accounting by correspondence. Desire work in Southeast or South America. Now employed in South Florida. PW-9777, Engineering News-Record.

GENERAL SUPERINTENDENT and Engineer, 27 years experience in complete charge of projects consisting of: Dirt moving, sewers, highways, bridges, mass concrete, caissons, tunnels and foundations. Available October 1, 1949, will go anywhere. PW-9812, Enginering News-Record.

CIVIL ENGINEER, 27, 6 years' experience in field and design-concrete and steel. Location secondary-foreign positions considered. PW-9811, Engineering News-Record.

STRUCTURAL ENGINEER: 34; 10 years broad experience in design of concrete, steel and wood buildings and industrial structures; Instructor 3 years, University of California; fully competent in Architecture and Mechanical Engineering; California license; executive ability. Seeks position of responsibility. Excellent references. Location, Western states. PW-9803, Engineering News-Record.

BUILDING CONSTRUCTION Superintendent, age 46, member A.S.C.E., 20 years experience, desires position with contractor or an Architect's representative. Prefer South but will consider any location. PW-9787, Engineering News-Record.

FIELD ENGINEER or Structural designer. Overseas. Eight years varied engineering experience. Hard working, intelligent, ambitious. Highest references. Single, 30. Resume on request. PW-9788, Engineering News-Record.

CHIEF DESIGNING Engineer, 25 years' experience in the structural design of industrial buildings, highway tunnels and bridge approaches, desires connection anywhere in the United States. PW-9790, Engineering News-Record.

SANITARY ENGINEER—Engineering faculty member, young, anxious to start at bottom in the sanitary engineering field. PW-9795, Engineering News-Record.

CIVIL-MECHANICAL. P.E. N. Y. Balanced experience consulting office, industrial plant operations, and field construction. Design, operation, maintenance utility and piping systems. Structural design industrial bldgs., waterfront structures, dams, highways. Can do own layout and drawings. Desires contacts upper N. Y., Far West, or Southwest. Small engr. office preferred. Civil Grad., 33, married, car, Protestant, not employed. PW-9784, Engineering News-Record.

CIVIL ENGINEER. 25 years of broad experience in design, estimate and supervision of construction as well as office administration. Considerable experience in Sewage Treatment Works and Water Purification Plants analysis, in Railroad Structures and concrete work. Preparation of plans, specifications and estimates. Seek responsible position. PW-9829, Enginering News-Record.

CONSTRUCTION ACC'T: 32, married, 4 yrs. overseas construction experience, office mgr., paymaster. 4½ yrs. domestic experience accountant, full charge bookkeeper, speaks some Spanish. If desired: wife, steno-secty experience, speaks French, German, Greek. Foreign preferred. PW-9826, Engineering News-Record.

STRUCTURAL ENGINEER Registered to take work in contract, design and details of all types of steel structures. Efficient service assured. PW-9828, Engineering News-Record.

(Continued on page 449)

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(Continued from page 448)

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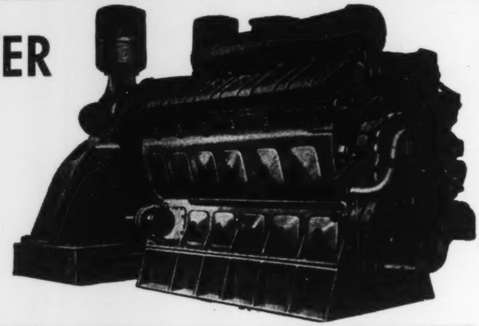

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625	Alco	6-12½x13	750	600
425	Baldwin	VO-6	510	450
375	Enterprise	DSG-6	450	450
312	General Motors	8-268A	450	1200
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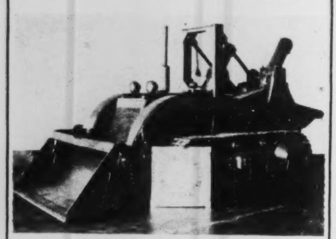

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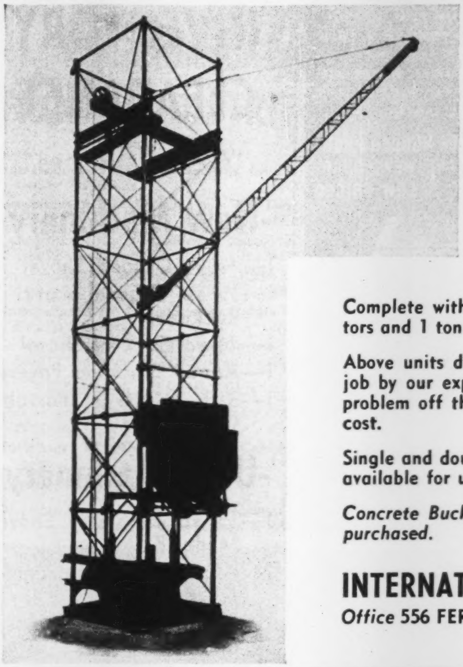

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26"	5	1/8"	1/32"
24"	5	1/8"	1/32"
24"	4	1/8"	1/32"
20"	5	1/8"	1/32"
20"	4	1/8"	1/32"
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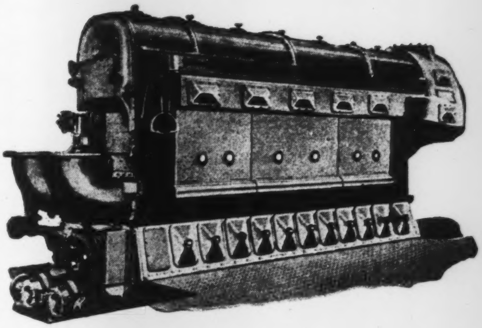

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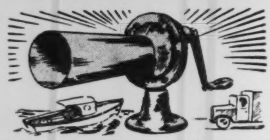

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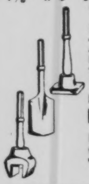

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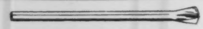

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Used 60 HP Vertical Boiler

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HYSTER TOWING WINCHES MODELS D8N—D7N

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Concrete Mixers of all sizes.

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Page 621S Dragline, Diesel, 6 yds., 135' boom.
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SEPTEMBER 8TH ISSUE OF ENGINEERING NEWS-RECORD

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Thursday, September 1st

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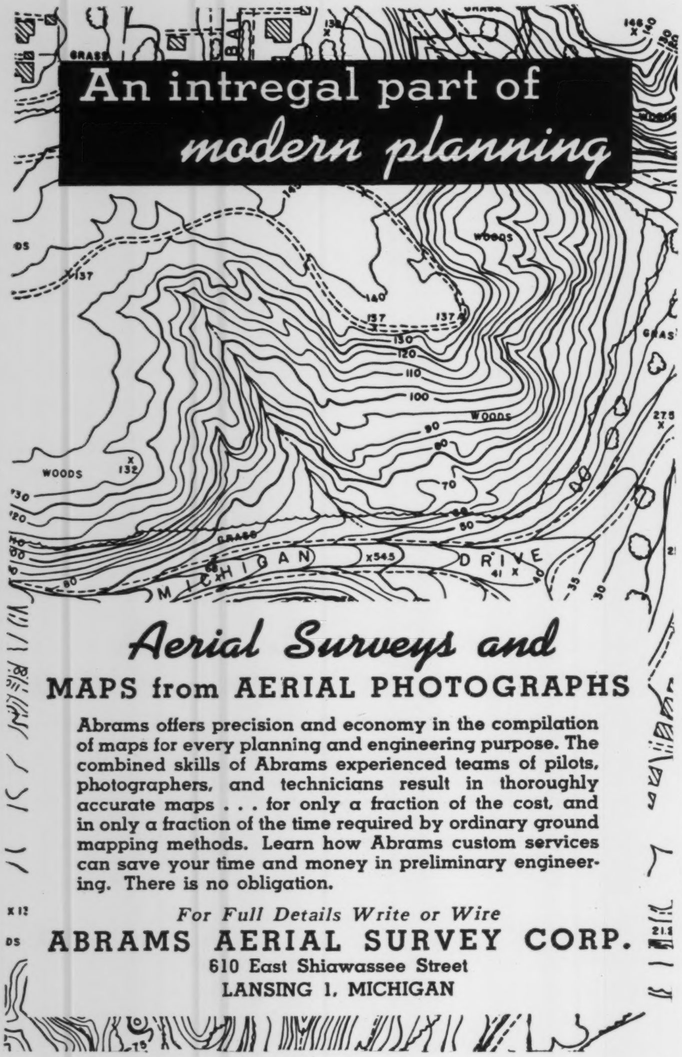

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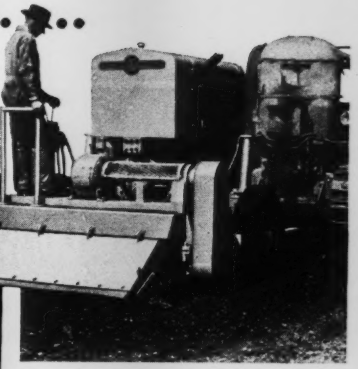

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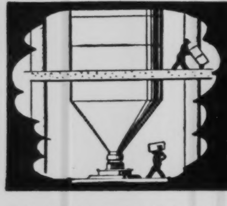

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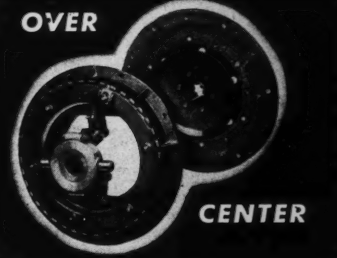

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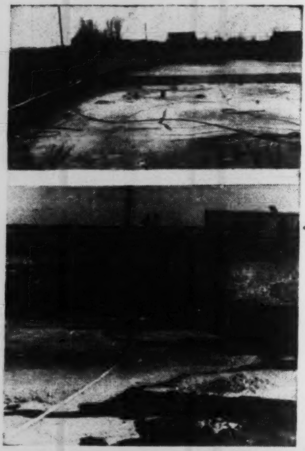

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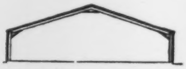

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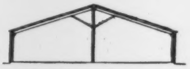

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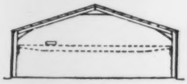

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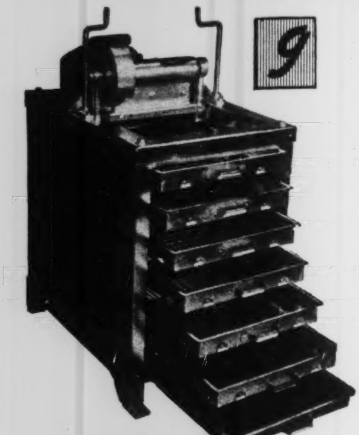

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One of the reasons for improved construction and reduced costs is the knowledge gained by testing materials and processes on the job.

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MERCER, PENNA.

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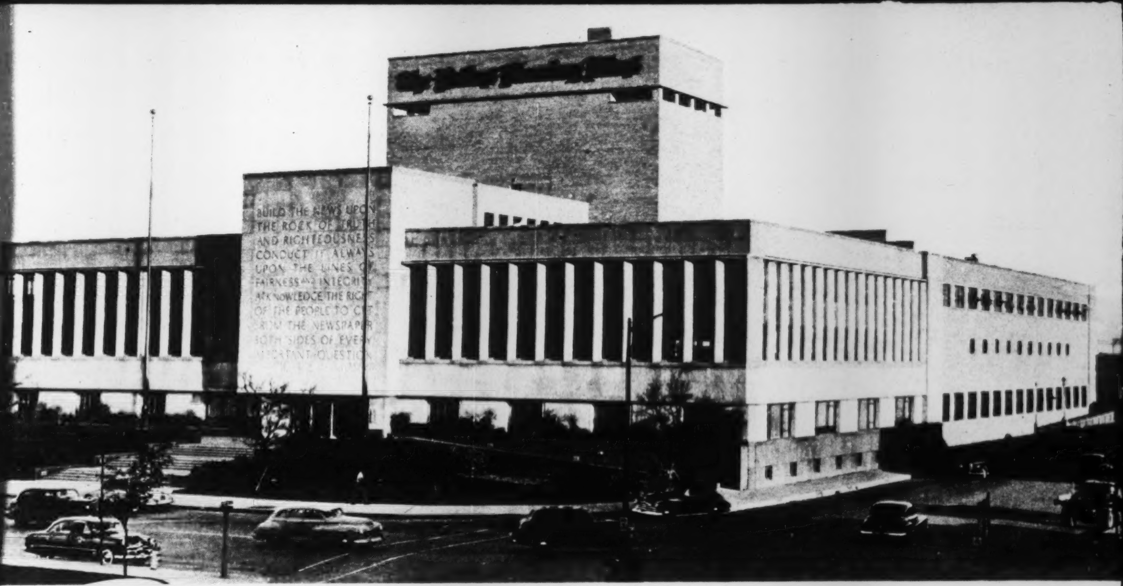

Dallas Morning News, Dallas, Texas. Archt.—George L. Dahl, Dallas; Consulting Engr.—William Ginsberg, New York City; Structural Engr. — Robert L. Rolfe, Dallas; Contr.—Henry C. Beck Company, Dallas. Pozzolith Ready-Mixed Concrete supplied by Dallas Concrete Company, Dallas.

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- **Prudential Insurance Co., Los Angeles, California.** Archts.—Walter Wurdeman and Welton Becket; Engrs.—Murray Erick Associates; Gen. Contr.—William Simpson Co., all of Los Angeles, Calif.
- **Tansley Bridge, Hamilton, Ontario.** Minister of Highways—Hon. Geo. H. Doucett; Deputy-Minister of Highways—J. D. Miller; Chief Bridge Engr.—Arthur Sedgewick, Toronto, Ont.; Gen. Contrs.—Therrien Construction Co. Ltd., Toronto, Ontario.
- **Radio Centro, Habana, Cuba.** Architects—Junco, Gaston, y Dominguez. Contractors — Purdy and Henderson. Structural Design — Ing. Jose A. Vila, Supt.: Ing. Bartolo Bestard. Pozzolith Concrete: Concretera Nacional, S. A.
- **The Kellog Company Warehouse, Battle Creek, Michigan.** Private Plans—Vern E. Alden, Chicago. Contr.—Herlihy Mid-Continent Co., Chicago

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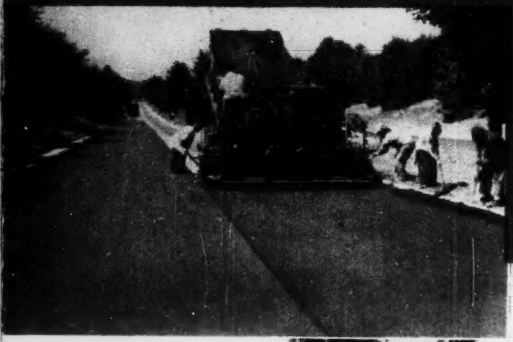

Two sections of the Merritt Parkway have been resurfaced with durable, joint-free Texaco Asphaltic Concrete by the Peckham Road Corporation, White Plains, N. Y. and Pavements, Inc., New Haven, Conn. The photo below brings out the skid-resistant texture of the new Texaco surface.

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